JAN 8 1929

The Engineer.

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VOL. CXLVI.—No. 3806] LONDON: FRIDAY EVENING, DECEMBER 21, 1928 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director - General, India Store Department, Belvedere-road, Lambeth, London, S.E. 1, invites TENDERS for :—

SCHEDULE 1.—15 BOILERS for 2ft. 6in. Gauge Locomotives.

SCHEDULE 2.—60 LOCOMOTIVE BOILERS and CONVERSION PARTS.

Tenders due on the 22nd January, 1929.

Forms of Tender available from the above at a fee (which will not be returned) of 5s. for each Schedule. 497

Crown Agents for the COLONIES.

COLONIAL GOVERNMENT APPOINTMENTS.

APPLICATIONS from qualified candidates are INVITED for the following POST :—

M/746.—ASSISTANT TOWN PLANNING SUPERINTENDENT REQUIRED by the GOVERNMENT of the FEDERATED MALAY STATES for four years' service, with possible permanency. Salary 400 dollars, rising to 800 dollars a month by annual increments of 25 dollars a month, plus an additional temporary non-pensionable allowance of 10 per cent. for bachelors and 20 per cent. for married men. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya is considerably less than that of 2s. 4d. in the United Kingdom. No income tax is at present imposed by the Federated Malay States Government. Free passages are provided. Candidates, aged 23 to 30, must have received a good theoretical training in Town Planning at a University or School recognised by the Town Planning Institute of Great Britain, or other such Diploma in Municipal Engineering and Surveying as the Secretary of State may consider adequate in any particular case. Must have a knowledge of Surveying, experience in the preparation of Municipal Town Planning and Housing Schemes. Site Planning and Replanning Schemes for existing areas is desirable.

Apply at once by letter, stating age and full particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/746. 494

The Assam-Bengal Railway COMPANY, Limited, is prepared to receive TENDERS for :—

STEEL WORK FOR EXTENSION TO JETTY NO. 4.

Specifications and Tender forms may be obtained at the offices of the Company, Bishopsgate House, 80, Bishopsgate, E.C. 2. A fee of £1 1s. is charged for each specification, which cannot under any circumstances be returned.

Drawings may be had at the cost of the tenderer by application to Messrs. Hodges, Bennett and Co., Ltd., 78, Queen Victoria-street, E.C. 4.

Tenders must be delivered at the Company's offices not later than Noon on Monday, the 21st January, 1929.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
THOS. C. BRETT,
Secretary.

18th December, 1928. 492

The Madras and Southern MAHRATTA RAILWAY COMPANY, Limited, invite TENDERS for :—

868.5 TONS (Approx.) STEEL WORK FOR STRENGTHENING 15 SPANS.

Tenders are due in on Monday, 7th January, 1929, by 2 p.m.

Tender form obtainable at address below ; fee One Guinea, which is not returnable.

The Directors do not bind themselves to accept the lowest or any Tender.

Company's Office :
25, Buckingham Palace-road,
Westminster, S.W. 1. 490

Bombay Port Trust.

APPLICATIONS are INVITED for the POST of SENIOR ASSISTANT ENGINEER (RAILWAY).

The pay of the post is in the grade (Rs. 600-50-1300) and the starting pay will depend on the qualifications and experience of the applicant.

The appointment is a temporary one. The period of agreement to be for five years.

The Engineer must have had experience in the construction and maintenance of Railways in dock areas and should be an Associate Member of the Institution of Civil Engineers.

Free first-class passages will be provided at the commencement and termination of agreement.

Leave and allowances to be in accordance with the rules in force for the Bombay Port Trust.

Applications, in writing, giving full particulars of training, experience, age and copies of testimonials, should be addressed to the CONSULTING ENGINEERS and AGENTS, Bombay Port Trust, 2, Queen Anne's-gate, Westminster, London, S.W. 1, not later than 1st January, 1929. 476

Derby Union.

INSTITUTION ENGINEER.

The Guardians invite APPLICATIONS from qualified men for the POSITION of WORKING ENGINEER at the Poor Law Institution, Derby, to Take Charge of Heating Installation, Steam Laundry, and similar Plant to be found in Poor Law Institutions.

Applicants to state age, whether married, experience, wages required, and when at liberty.

Applications must be received by the undersigned not later than first post of Thursday, the 3rd January, 1929.

RALPH GRANTHAM,
Clerk to the Guardians.

Poor Law Offices, Derby. 472

Sudan Government Railways and STEAMERS REQUIRE the SERVICES of an ASSISTANT CIVIL ENGINEER. Age 26 to 32 years, preferably single. Candidates should possess A.M.I.C.E. Degree and should have had practical experience in Railway Construction and Maintenance as Civil Engineer on a British Railway. Eighteen months' contract. Starting rate of pay £E480-540, according to age and qualifications. Strict medical examination.—Apply by letter, with full details of training and experience, to ADVISORY ENGINEER, Sudan Government London Office, Wellington House, Buckingham-gate, S.W. 1, marking envelope "Asst. Civil Engineer, S.G.R." 487

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE.
ARRANGED FOR CARD INDEXING.

Machines for Building the Cauvery Dam. (P. 683)
THE ENGINEER, 21 - 12 - 28.

Mercury Vapour Rectifiers. (P. 680)
THE ENGINEER, 21 - 12 - 28.

Three-Cylinder Narrow Gauge Locomotives for Colombia. (P. 681)
THE ENGINEER, 21 - 12 - 28.

Thin Cylinders of Non-Circular Section. (P. 676)
(H. W. SWIFT.) THE ENGINEER, 21 - 12 - 28.

Vancouver Harbour. (P. 676)
THE ENGINEER, 21 - 12 - 28.

Continuously-Loaded Submarine Cables. (P. 690)
THE ENGINEER, 21 - 12 - 28.

The Engineering Congress in Japan. (P. 690)
THE ENGINEER, 21 - 12 - 28.

Cable Charge and Discharge. (P. 686)
(F. G. W. TREE.) THE ENGINEER, 21 - 12 - 28.

Institution of Mechanical Engineers : Report on Machinability. (P. 692)
(E. G. HERBERT.) THE ENGINEER, 21 - 12 - 28.

The Condenser Puzzle Again. (P. 689)
THE ENGINEER, 21 - 12 - 28.

INDEX TO ADVERTISEMENTS, PAGE 83.

PUBLIC NOTICES

Great Western Railway.

The Directors of the Great Western Railway Company have FOR DISPOSAL GAS ENGINES and DYNAMOS, which can be seen in commission at Swindon.

Applications to view should be made to Mr. A. C. Cookson, the Company's Stores Superintendent at Swindon, Wilts., from whom full particulars may be obtained.

F. R. E. DAVIS, Secy.

Paddington Station, London, W. 2. 424

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED

WANTED for a Firm of English Structural Engineers in India, an OFFICE MANAGER and CHIEF DESIGNER. Knowledge of Bridge Work essential and must have had both works and administrative experience. Age about 35. Commencing remuneration the equivalent of £2000 per annum, with excellent prospects.—Write, with full particulars of career and, if possible, a photograph, to Z.G. 206, c/o Deacon's Advertising Agency, Fenchurch-avenue, London. All applications will be treated as strictly confidential. 469 A

BLUE PRINTING, PHOTOGRAPHY.—MAN REQUIRED, to Take Charge of Blue Prints, Drawing Stores, Filing System of Drawings, and to Take Photographs in engineer's office. Good remuneration to right man.—Address, stating age, references, salary required, and full particulars, &c., 481, The Engineer Office. 481 A

COMMERCIAL ENGINEER AND SALES MANAGER.—WANTED for a Factory in the South of England, SALES MANAGER, having extensive knowledge of engineering workshop practice and procedure, together with experience on the sales side. Knowledge of sales methods in colonial and foreign markets is essential, and no applicant will be successful unless he can show that he has an established connection both at home and abroad.—Address, with a statement of experience and copies of any testimonials, P5275, The Engineer Office. P5275 A

CENTRIFUGAL PUMP DESIGNER.—WANTED, an experienced SENIOR, well versed in modern practice. State age, experience, and salary. Applications treated in confidence.—Address, 500, The Engineer Office. 500 A

SITUATIONS OPEN (continued)

DESIGNING ENGINEER REQUIRED, Experience Bucket Elevator, Concrete Plant. Sound practical draughtsman. State age, experience, salary required.—Address, P5302, The Engineer Office. P5302 A

ENGINEER, Experienced in Supervising Steel Work Erection Contracts and Maintenance Cranes, Plant, &c.—Address, P5299, The Engineer Office. P5299 A

ENGINEERING PUBLICITY.—Important FIRM in S.E. England REQUIRE ASSISTANT. Some engineering knowledge and publicity experience essential. Send concise statement of qualifications and, if possible, examples of work. State age, salary required, and when able to commence.—Address, 499, The Engineer Office. 499 A

ENGINEERS, Supplying Highly Developed INDUSTRIAL MACHINERY, are OPEN to EMPLOY well-educated competent ENGINEERS as ERECTORS —ultimate end in view SELLING. Applicants should not be over 32 and must be of good appearance and of ready address. They must be prepared to prove their suitability by satisfactorily performing preliminary duties allocated to them which may extend for a period of two years. Give only particulars of education and technical qualifications and apply for application form.—Address, 486, The Engineer Office. 486 A

INDIA.—Young, Unmarried ASSISTANT REQUIRED for Calcutta Office of Company manufacturing Permanent Way appliances. Sound health, good education, and some previous commercial experience essential. Knowledge of engineering an advantage.—Address, stating age, where educated, experience, &c., to 502, The Engineer Office. 502 A

MECHANICAL ENGINEER WANTED for the Near East, with experience abroad, in charge of workshops and erection and maintenance of Heavy Contractors' Modern Plant for Excavation and Bridge Work. Age about 35.—Address, with full particulars and copies of testimonials, 479, The Engineer Office. 479 A

REQUIRED, as BUSINESS MANAGER and SALES ORGANISER, for a new article of universal appeal to the engineering world, an energetic MAN of good education and address with proved sales record in similar connection.

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SITUATIONS OPEN (continued)

PHOTO BLUE PRINTING.—MAN WANTED, to Take Charge of Manufacturing Engineers' Blue Printing Room and Drawing Files. Knowledge of Hall's Rotary Photo Copiers and modern Blue Printing, Photostat, and Reproduction Processes essential, together with experience of routine filing and card indexing.—Address, stating age, experience, and salary required, 377, The Engineer Office. 377 A

WORKS MANAGER.—Experienced MAN WANTED for POST of WORKS MANAGER in Small Engineering Works employing 40 to 50 hands in Light Engineering Trade where fine and accurately finished products are manufactured. State experience, wages required, &c.—Address, P5311, The Engineer Office. P5311 A

WANTED, First-class CARRIAGE and WAGON DRAUGHTSMEN ; experienced men only.—Apply, giving particulars of experience, salary required, &c., to THE BIRMINGHAM RAILWAY CARRIAGE and WAGON CO., Ltd. Smethwick. 453 A

WANTED, DRAUGHTSMAN, with Experience of Power Station Details, Steel Work, Foundations, Piping, &c. Some electrical experience desirable. London area. Applicants must state experience, age, and salary required.—Address, P5291, The Engineer Office. P5291 A

DRAUGHTSMAN, Experienced in Centrifugal Pump design, to concentrate particularly on development and experimental work. Good salary and permanent position to suitable man. State age, experience, and, if possible, give references in confidence.—Address, 482, The Engineer Office. 482 A

DRAUGHTSMAN REQUIRED by Midland Firm of Constructional Engineers. Must be fully qualified to design and estimate for Steel-framed Buildings, Lattice Girders, Towers, &c.—Address, with full particulars and salary required, 372, The Engineer Office. 372 A

DRAUGHTSMAN REQUIRED for Glasgow District. Expert designer of Light Steel-framed Buildings and General Structural Work, preferably with experience in design of Masts for Electric Overhead Transmission. State age, experience, where gained, salary required, and when free.—Address, 493, The Engineer Office. 493 A

DRAUGHTSMEN, Senior and Junior, REQUIRED, used to Pressed Metal and Light Steel Construction Work.—Apply by letter, stating age, experience, and salary required, to the AUSTIN MOTOR CO., Ltd., Longbridge, Birmingham. 484 A

DRAUGHTSMAN, SENIOR, for Constructional Steel Works, Manchester district. Must be keen designer and good mathematician. Must have had 10 years' previous experience in similar work. State age, references, and when at liberty.—Address, 498, The Engineer Office. 498 A

DRAUGHTSMAN, SENIOR, with First-class Experience of Steam Turbine Design and Details.—Apply, stating age, experience, and salary required, to MANAGER, Drawing-offices, B.T.H. Co., Ltd., Rugby. 457 A

INDIA.—REQUIRED CARRIAGE and WAGON ESTIMATOR DRAUGHTSMAN. Must have good knowledge of design ; also experience in large Carriage and Wagon Works. Five years' agreement, free passage out and home, single man preferred.—Write, with full particulars of experience and copies of testimonials, to Z. C. 224, c/o Deacon's Advertising Agency, Fenchurch-avenue, London. 503 A

JUNIOR DRAUGHTSMAN, for London District, REQUIRED, experienced in Light Structural Steel Work, Hoppers, Bunkers, and Plate Work.—Address, P5300, The Engineer Office. P5300 A

MECHANICAL ENGINEERING DRAUGHTSMEN WANTED, preferably with Aircraft experience, to commence duties New Year.—Written application, with full details of training and salary required, to CHIEF ENGINEER, Fairey Aviation Company, Limited, Hayes, Middlesex. 475 A

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SENIOR DRAUGHTSMAN and DESIGNER WANTED, with good experience in the design of the latest type Commercial Vehicle Chassis.—Address, giving full particulars of experience, age, and salary required, 478, The Engineer Office. 478 A

TEMPORARY DRAUGHTSMAN WANTED IMMEDIATELY. Experience in detail work design on Air Compressors essential. Salary £4 10s. per week. —Address, stating age, experience, &c., 480, The Engineer Office. 480 A

SITUATIONS OPEN (continued) Page 2.
SITUATIONS WANTED, Page 2.
AUCTIONS, Page 84.
BUSINESSES and PREMISES (For Sale, etc.). Page 84.
MACHINERY, &c., WANTED, Page 84.
EDUCATIONAL, Page 2.
PATENTS, Page 84.
MISCELLANEOUS, Page 2.
AGENCIES, Page 2.
FOR SALE, Page 84.
WORK WANTED, Page 2.
FOR HIRE, Page 84.

For Advertisement Rates see Leader Page.

SITUATIONS OPEN (continued)

TWO SENIOR DRAUGHTSMEN REQUIRED: One Heating and One Ventilating. Both must be capable of handling enquiries and contracts in their entirety and to take charge of their departments as and when necessary.—Address, 458, The Engineer Office. 458 A

FOREMAN for Gear Cutting Shop. Must be Real live man and able to do own setting, preferably with a knowledge of Worm Grinding.—State full particulars of experience and class of machines, age, and salary.—Address, Box 241, Wheeler's Advertising Agency, Manchester. P5306 A

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For continuation of Small Advertisements see page 84.

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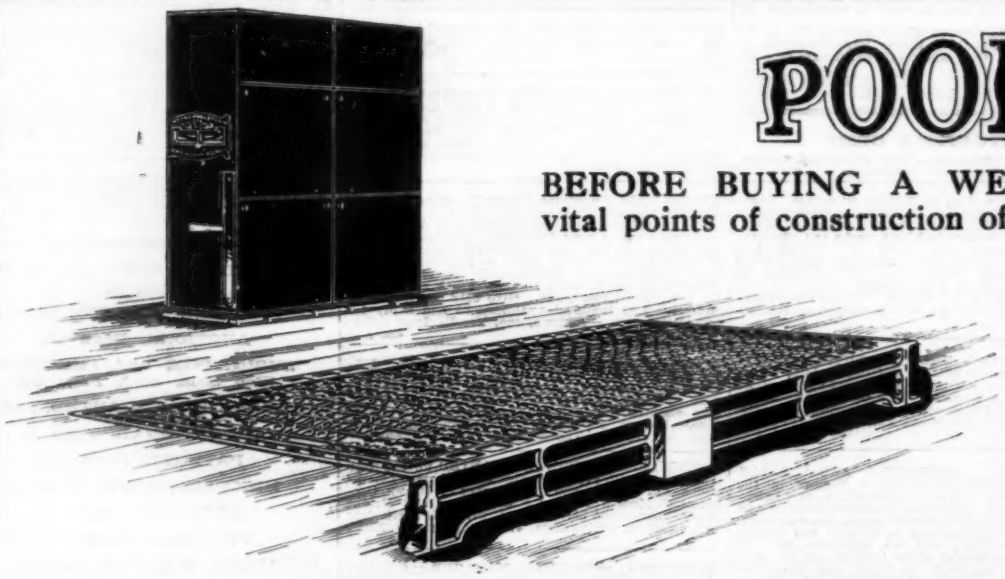

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X 325

A Seven-Day Journal

Two Important Amalgamations.

IT is announced by Messrs. Vickers, Vickers-Armstrongs and Cammell Laird, that two agreements have been concluded, subject to certain consents, which have yet to be obtained. The first agreement, to which all three firms are parties, provides for the amalgamation of the whole of their steel interests, with the exception of those concerned with guns, gun mountings, and armoured cars and tanks. A new company, to be called the English Steel Corporation, Ltd., will be formed for the purpose of taking over these steel interests. The Corporation will take over from Vickers-Armstrongs the River Don Works, Sheffield—with the exception of certain gun making plant and plant for armoured cars and tanks; the Attercliffe Works, Sheffield; the Holme-lane Works, Sheffield; the Openshaw Works, Manchester—with the exception of the gun mounting plant; and the plant for drop forgings at Elswick. From Vickers Ltd., the Corporation will take over the ordinary shares in Taylor Brothers and Co., Ltd., steel tire, axle and wheel manufacturers, of Trafford Park, Manchester; and from Cammell Laird and Co., Ltd., the Cyclops Steel and Ironworks, Sheffield; the Grimesthorpe Works, Sheffield; and the Yorkshire Steel and Ironworks, Penistone. Negotiations are also in progress for including in the new company other important firms in the steel industry. The second agreement to which Vickers Ltd., and Cammell Laird and Co., Ltd., are parties, provides for the amalgamation of all the railway carriage and wagon interests of the two companies. For this purpose the name of the Metropolitan Carriage, Wagon and Finance Company, Ltd., which is a subsidiary of Vickers, will be changed to the Metropolitan Cammell Carriage, Wagon and Finance Company, Ltd., and the carriage and wagon interests of Cammell Laird will be transferred to it. The Metropolitan Cammell Carriage, Wagon and Finance Company, Ltd., will therefore comprise the following firms from Vickers Ltd., the Metropolitan Carriage, Wagon and Finance Company; the Patent Shaft and Axletree Company; and the Willingsworth Iron Company; and from Cammell Laird and Co., Ltd., the Nottingham Factory, and their interest—which includes practically the whole of the issued ordinary shares—in the Midland Railway Carriage and Wagon Company, Ltd., and in the Leeds Forge Company, Ltd. It should be noted that these agreements cover only the steel and railway carriage and wagon interests of Messrs. Vickers, Vickers-Armstrongs and Cammell Laird, and that their other activities are unaffected and will be carried on as heretofore.

Further Amalgamations.

FOLLOWING the announcement of the Vickers-Armstrongs—Cammell amalgamations, it was confirmed that negotiations are proceeding between Dorman, Long and Co., Ltd., and Bolckow, Vaughan and Co., Ltd., for a fusion of their interests. Both these Middlesbrough firms are iron and steel manufacturers, and colliery and ironstone mine owners, and are interested in bridge building and constructional engineering, Dorman, Long directly and Bolckow, Vaughan through their associated company, Redpath, Brown and Co., Ltd. Another amalgamation announced this week is that of the South Durham Steel and Iron Company, Ltd., and the Cargo Fleet Iron Company, Ltd.

"An Authorised Nuisance."

ON July 17th this year judgment was pronounced in the Civil Court at Manchester Assizes, in a case in which the Corporation of Manchester was sued by Mr. Arthur Farnworth, of Promyhurst Farm, Barton-upon-Irwell, for alleged damage to crops in the neighbourhood of Barton Power Station. The plaintiff stated that from the 550 tons to 560 tons of coal consumed per day at the station, about 11 tons of sulphur in one form or another were discharged into the air, and that the fumes blown along the ground ruined the vegetation and crops in the vicinity. For the defence, it was claimed that it was not possible to generate electricity or create power by burning coal without sending sulphur dioxide into the air, that the nuisance could not be mitigated, and that the Corporation was entitled in this matter to be a nuisance. Mr. Justice Talbot gave judgment for the Corporation, which, he said, was entitled to succeed on the ground that the nuisance which otherwise would have been objectionable, had been authorised by Parliament. Mr. Farnworth carried the case to the Court of Appeal, and on Thursday of last week his appeal from Mr. Justice Talbot's judgment was allowed with costs, and damages up to the date of the appeal. Giving judgment in Mr. Farnworth's favour, Lord Justice Scrutton added that there ought also to be an injunction to restrain the Corporation from committing a nuisance by fumes from its station, but that the injunction should be suspended for a year to enable the Corporation to do as it was advised to mitigate the nuisance. The case, he said, showed the necessity for Parliament and other authorities giving careful attention to provisions for compensation for damage following the great development of electrical power stations. Lord Justice Lawrence agreed with Mr. Justice Talbot, and held that the appeal should be dismissed, but Lord Justice Sankey supported Lord Justice Scrutton, and the appeal accordingly was allowed.

Twenty-five Years of Flight.

MONDAY last, December 17th, marked the passage of a quarter of a century since the day on which the brothers Wright made the world's first flights in a power-driven heavier-than-air machine. The first flight at Kitty Hawk, North Carolina, on December 17th, 1903, was made by Mr. Orville Wright in the presence of his brother and four witnesses. It lasted 12 seconds. The late Mr. Wilbur Wright next flew the machine, and then Mr. Orville again. Mr. Wilbur took it up for a fourth flight, and in the face of a 20-mile wind covered 852ft. in 59 seconds. After the fourth flight the machine was rolled over by a gust of wind and wrecked. It was subsequently carefully repaired—the restoration even going so far towards exact similitude as the obtaining of the linen fabric of the same quality as the original from the same stores. The machine, following a dispute with the Smithsonian Institute at Washington, was last year handed over to the keeping of the Science Museum at South Kensington. To celebrate the quarter-centenary of the first flight, a granite boulder with a memorial tablet was unveiled at Kitty Hawk in the presence of aeronautical representatives from thirty different nations. Mr. Orville Wright and the four eye-witnesses of his and his brother's historic achievement were also present. In London a distinguished company of scientists, aircraft constructors and aeronautical research workers took part in a dinner organised at the Science Museum by the Royal Aeronautical Society. Much interest was added to the proceedings by the fact that over the diners' heads there hung the machine in which the brothers flew twenty-five years ago.

Automatic Street Traffic Signals.

IN our "Sixty Years Ago" paragraph in last week's issue we described a traffic control signalling device which was tried in London in 1868, and of which much was expected in the way of the improved regulation of the traffic congestion which even in those days characterised the busier thoroughfares and crossings in the Metropolis. To round off our note we called attention to a modern traffic signalling device described in our issue of May 4th this year, with which the Metropolitan Police have been experimenting. Somewhat unkindly, perhaps, we commented upon the fact that after a period of sixty years the constable's arm still dominated the situation. We wrote a week too soon. Had we held our pen for another seven days we would have been able to credit Coventry with an economical solution of the problem, which, after the first two hours of its operation on Monday of this week, drew from the Chief Constable of the town an expression of delight at the manner in which it was working. At a certain busy crossing four standards are erected, one at each corner. Each standard carries three lights, a red, an amber, and a green. The lights are displayed automatically at intervals, which can be regulated to suit the traffic conditions. During normal hours it was found to answer well if the "all clear" and "stop" signals were displayed for periods of 35 sec., including a period of 5 sec. during which the amber light was shown to indicate that the signal was about to be changed. It was found that lorry drivers and pedal cyclists were less observant than car drivers and motor cyclists, but that on the whole drivers, both local and from a distance, quickly grasped the idea. According to the Chief Constable of Coventry, the yearly cost of the installation will be only £10, as compared with £400 required to work the point properly by man power. The idea is not indigenous to Coventry or even, we are sorry to say, to this country. It has for some time been in extensive use in America.

A New Cross-Channel Steamer.

ON Thursday of last week, December 13th, there was launched from the yard of William Denny and Brothers, Ltd., at Dumbarton, the new twin-screw cross-Channel steamer "Canterbury," which has been built to the order of the Southern Railway Company for the Dover and Calais boat service connecting with the "Golden Arrow" train for Paris and the South of France. The new ship has the same length as the previous vessels—namely 329ft.—but she is broader. The decks are specially protected against weather and the passenger accommodation is of a particularly high order, with a Royal suite and observation room on the boat deck. Twin-screw turbine machinery of the Parsons geared type will be installed and the four 225 lb. pressure boilers, of the Babcock and Wilcox water-tube type, will be oil fired. The "Canterbury" has a measurement of 3100 gross tons, which is about double that of the cross-Channel steamer "Riviera," which was constructed by Dennys in 1911. The naming ceremony was performed by Lady Walker, the wife of Sir Herbert A. Walker, the general manager of the Southern Railway Company. In his reply to the toast of "The New Ship," which was proposed by Mr. Maurice E. Denny, Sir Herbert stated that since the amalgamation of the three railways six years ago no less than twenty-two new steamers had been put into commission. Six out of that number were express passenger ships, and they had all been built by Wm. Denny and Brothers, Ltd. Out of a total expenditure of over £1,500,000, about two-thirds had been spent at Dumbarton. The Southern Railway Company was at the present time, Sir Herbert went on to say, considering the question of ordering two more cross-Channel steamers for the 1930 Channel Islands service.

Charing Cross Bridge.

THE promise held out some time ago that agreement was about to be reached between the Ministry of Transport, the London County Council, and the Southern Railway over the proposal to remove Charing Cross Station to the south bank of the Thames, in order to permit a road bridge to be constructed on the site of the existing railway bridge, appears to have been delusive. At a meeting of the London County Council on Tuesday of this week, the Chairman of the Improvements Committee stated that the negotiations begun last July had not yet been concluded. The decision of the railway company was still awaited, and it was impossible to forecast when it would be given. The company, it seems, has submitted to the Ministry of Transport an amended plan of its proposals for the laying out of the site on the south bank of the river. It must not, however, be thought that difference of opinion as to the manner in which the new site for the station shall be laid out is the sole or even the principal cause of the delay in reaching agreement over the scheme. Large financial questions are also involved, and are still under examination. The Council regards the subject as urgent, and has protested against the delay in reaching an agreement with the railway company. It has been stated by the railway company that whatever agreement it reaches with the Council and the Ministry must be ratified by its shareholders before it can become the company's final decision in the matter.

A New Bridge Across the River Tees.

AT a conference which was held at Middlesbrough last week it was decided to construct a road bridge across the river Tees at Newport, at a cost of about half a million pounds. It is necessary to ensure a clear passage for river traffic, and consequently the bridge is to be designed with a centre lifting span which will give a clear river channel 325ft. wide. The proposal to drive a tunnel below the river was negatived on the grounds of the depth at which the tunnel would have to lie to ensure sufficient cover after the bed of the river had been dredged deep enough for large ocean-going liners. To allow for this depth it was computed that the roadway would need to be 90ft. below the ground level on the shore at either side of the river, which would mean approaches at least half a mile in length with a gradient of 1 in 30. In addition, the bridge would be completed much earlier than a tunnel. It was decided that a sub-committee should approach the Ministry of Transport for the necessary permission to build the bridge, and ascertain what grant the Ministry would be prepared to make towards the cost of the work. The conference was attended by representatives of the Middlesbrough Corporation and the various County Councils having interests in the proposed bridge, the Tees Conservancy Commission, the London and North-Eastern Railway Company, Dorman, Long and Co., Ltd., and the Ministry of Transport.

The Salving of the Celtic.

As indicated in our Journal note of last week, steps were at once taken to salve the cargo on the stranded White Star liner "Celtic," which went aground at the entrance to Cork Harbour on Monday morning, December 10th. As the ship is only accessible from one side and is exposed to both south-easterly and south-westerly winds, fine weather is essential if the operations are to be successfully carried out. During the past week some bad weather has been experienced and the progress with the work of salvage has been necessarily slow. A complete examination of the ship which was made on Monday last revealed, we understand, signs of serious straining on the decks immediately forward of the boiler spaces, while the lower deck had been set up and fractured in several places over a wide area. A pumping test which was made in the machinery spaces showed that extensive damage had been done to the bottom of the ship and that the damaged parts were very difficult of access. Under these circumstances those in charge of the salvage operations have advised the owners that further expense in trying to salve the ship cannot be justified. The very exposed position in which the ship lies at present, together with the difficulty experienced by craft in getting alongside, further complicates the problem. Even under the best conditions of weather the discharge of the cargo will be a slow process, and it is suggested that the work should be carried out with as great economy as possible.

Thin Cylinders of Non-circular Section.

By H. W. SWIFT, M.A., D.Sc.

THE treatment of the stresses in thin cylinders to be found in text-books and general engineering instruction is virtually confined to the elementary problem of a circular cylinder under uniform internal pressure. This limitation no doubt arises from the extreme simplicity of the elementary problem and the genuine difficulties introduced either by a non-uniform pressure or by cylinders of non-circular section. Yet both these problems have their practical value, for it will be found that non-uniform pressure round the shell introduces quite important stresses in the case of an ordinary Lancashire boiler, for example, and the design of hydraulic valve bodies frequently involves the problem of the non-circular cylinder.

A graphical method whereby the tension, shearing force and bending moment at various points in the shell of a non-circular cylinder under uniform internal pressure may be estimated has been proposed by A. T. Weston.* Although referred to as simple by Morley, this method involves the drawing of a large number of normals to the cylinder bounding curve, the step-by-step construction of a funicular polygon, and computation of the "primary" bending moment at each point by multiplying two numbers scaled from the diagram. From the mean ordinate of this primary bending moment diagram the "fixing" moments at the ends of the principal diameter are determined and the true bending moment diagram constructed. Apart from the labour involved, the step-by-step construction of the funicular polygon introduces a source of systematic error which, although it operates in the direction of safety, is unsatisfactory.

In the most general case it is difficult to see how the construction, or at least the computation, of the "primary" bending moment diagram can be avoided, but the work involved may be reduced very considerably by a somewhat different application of mechanical principles, and in some cases the "leading" bending moments may be estimated directly and expeditiously.

Consider the section of any cylinder which is symmetrical about each of two perpendicular axes $A_1 A_2$ and $B_1 B_2$ in Fig. 1, and is subjected to an internal pressure of uniform intensity p.

Then at the point A_1 there will exist :—

(*a*) A tension T_a in the shell given by $T_a = p \,.\, a$, where a is the semi-diameter $O A_1$.

(*b*) No shearing force, by virtue of symmetry.

(*c*) A bending moment which may be regarded as the "fixing moment" and designated as M_a.

At any other point P there will act :—

(*a*) A force of magnitude $T = p \,.\, O P$ acting perpendicular to the radius vector O P and giving rise in general to tensile and shearing components. This fact is proved quite simply by a consideration of the forces acting on the portion $A_1 P$ of the shell, for which $O A_1 P$ is the triangle of forces turned through a right angle.

(*b*) A bending moment which, by considering the forces shown in Fig. 1, may be written in the following form :—

$$M = M_a + T_a \,.\, N A_1 - p \,.\, \frac{P A_1^2}{2}$$

$$= M_a + p \,.\, O A_1 \,.\, N A_1 - \tfrac{1}{2} p \,.\, P A_1^2$$

$$= M_a + \frac{p}{2}(a^2 - r^2),$$

where r is the radius vector O P.

Neglecting for the moment the fixing moment M_a in this expression, the "primary" bending moment diagram may therefore be plotted, if desired, as $M^1 = \frac{p}{2}(a^2 - r^2)$, the various values of r being scaled from the drawing of the section.

The value of the fixing moment M_a is determined by the condition that the line integral $\int M \,.\, d\,s$ vanishes along a quadrant of the shell section, provided the thickness of the metal is assumed uniform. This condition arises, of course, from the fact that the angular displacement at each end of the quadrant is nil. It follows that :—

$$\int [M_a + \frac{p}{2}(a^2 - r^2)]\, d\,s = 0,$$

$$i.e., \; M_a + \frac{p\,a^2}{2} = \frac{p}{2} \frac{\int r^2 \,.\, d\,s}{\int d\,s} = \frac{p}{2} \,.\, k^2$$

where k is the polar radius of gyration of the shell about its axis. The fixing moment is therefore given by :

$$M_a = \frac{p}{2}(k^2 - a^2),$$

and the bending moment at any point of the section by :

$$M = \frac{p}{2}(k^2 - r^2).$$

This form of expression for the bending moment assumes no special shape of cylinder and is quite general for any section which is biaxially symmetrical and whose shell is of uniform thickness. No further simplification suggests itself in the general case but the method of computation may now be reduced to a comparatively simple process of tabulation.

Let a quadrant of the cylinder section be drawn as indicated in Fig. 2, and a number of equal lengths of arc marked off round the curve. It is important that equal lengths of arc, not equally spaced ordinates, should form the basis of division, but it is not necessary that the curve should be divided into an exact number of parts. From the drawing the dimensions indicated in the figure as r, n, t are scaled off and tabulated. The lengths n, t are conveniently measured by means of a graduated set square, and, in point of fact, need only be scaled off for those points at which it is desired eventually to determine the stresses completely.

From the values of n and t the corresponding hoop tensile and shear stresses may be computed, though it will commonly be found that the shear stress is insufficient to affect the maximum fibre stress and that its measurement is really unnecessary.

From the measurements of r values of r^2 may be tabulated, and the mean value of r^2 gives the radius of gyration k^2. This determines the fixing moment M_a and also enables the values of $k^2 - r^2$ to be tabulated. This need only be done for those points of the section at which it is required to calculate the stresses. The next and virtually the last column may now be completed to show either the bending moment at various points, or, by the use of a different slide-rule

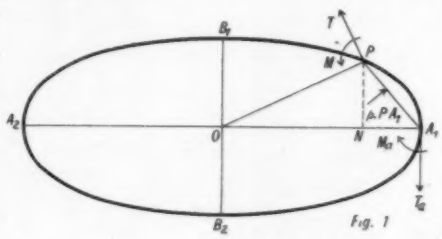


Fig. 1

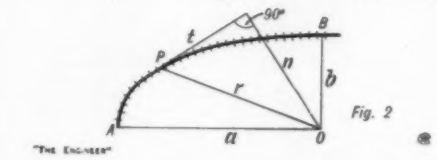


Fig. 2

FIGS. 1 AND 2

constant, the maximum fibre stress due to bending $f_1 = \frac{3p}{h}(k^2 - r^2)$, where h is the thickness of the shell.

TABULAR SCHEME FOR COMPLETE STRESS CALCULATION.

Column 1 : r.
Column 2 : r^2. k^2 = mean value of r^2.
Column 3 : $k^2 - r^2$.
Column 4 : $M = \frac{p}{2}(k^2 - r^2)$ or $f_1 = \frac{3p}{h^2}(k^2 - r^2)$.
Column 5 : n.
Column 6 : $f = \frac{p}{h} n$.
Column 7 : Total tensile stress $f_1 + f_2$.
Column 8 : t, if necessary.
Column 9 : $s = \frac{p}{h} \,.\, t$, if necessary.

NOTE.—Columns 3 onwards need only be completed for those points at which the stress is to be completely determined.

If, as will frequently be the case, it is only required to calculate the stresses at the ends of the principal axes of the section, then the tabular scheme is unnecessary ; r alone need be scaled from the drawing and k^2 determined as the mean value of r^2. Then, if a, b are the principal semi-diameters of the cylinder, the maximum fibre stresses are :—

$$f_a = \pm \frac{3p}{h^2}(k^2 - a^2) + \frac{p\,a}{h}$$

$$f_b = \pm \frac{3p}{h^2}(k^2 - b^2) + \frac{p\,b}{h}$$

In those cases for which the value of the radius of gyration can be calculated or is known the complete solution is a simple and direct matter. The leading values of the bending and hoop stress may be found by means of direct measurements from the section, and no tabulation is necessary unless the complete bending moment diagram is to be drawn.

In the case of a rectangular section, for example, it is easily shown that

$$k^2 = \frac{(a + b)^2}{3}$$

where a, b are the semi-axes, so that the general expression for the bending moment becomes :—

$$M = \frac{p}{2}\left\{\tfrac{1}{3}(a + b)^2 - r^2\right\}$$

and its values at the mid points of the sides and at the corners are easily found. The hoop tension and shearing force are calculable by elementary methods.

Another case which may be calculated exactly in this way is that of a section composed of two parallel sides, of length $2a$, joined by semi-circular ends, of radius r, such as is sometimes employed for the bodies of hydraulic sluice valves. In this case

$$k^2 = a^2 + r^2 + \tfrac{1}{4} \,.\, \frac{a}{a + \frac{\pi r}{2}}(3r^2 - a^2).$$

In what is probably the most important case of a non-circular cylinder, that of elliptical section, direct computation of the radius of gyration involves elliptic integrals and is not therefore a method suited to general use. The difficulty may be removed, however, by the compilation once for all of a table showing the value of k for ellipses of various excentricities. The values given in the table below have been determined by the author by a semi-graphical method and checked by integration in series, and will be found sufficiently accurate for all ordinary purposes of design. From this table the value of k may be estimated in terms of the semi-axes a, b of the ellipse, either directly or by interpolation, for any value of the ratio $\frac{b}{a} = m$. It is noteworthy that for values of m greater than about 0·4 it will generally be sufficiently accurate to take $k = \frac{a + b}{2}$. For flatter ellipses the correction factor shown as C in the table will be found convenient.

Radius of Gyration for Elliptical Shells.

$\frac{b}{a}$	$\frac{k}{a}$	$C = \frac{2k}{a + b}$
0·9	·950	1·00
0·8	·900	1·00
0·7	·850	1·00
0·6	·801	1·001
0·5	·752	1·002
0·4	·704	1·006
0·3	·660	1·015
0·2	·620	1·034
0·1	·591	1·074
0·0	·577	1·154

As an example, take the case of a sluice valve body whose section is in the form of an ellipse 64in. by 21in., working under an internal pressure of 200 lb. per square inch. The bending moments at the ends of the axes are found as follows :—

$$\frac{b}{a} = \frac{21}{64} \qquad c = 1{\cdot}015 \qquad k = 21{\cdot}6\text{in.}$$

The general expression for the bending moment is :—

$$M = 100\,(467 - r^2)\ \text{lb.-in. per inch.}$$

and its leading values are :—

M_a = 53,000 lb.-in. per inch.
M_b = 36,000 lb.-in. per inch.

Mr. H. Tart, of Messrs. J. Blakeborough and Sons, Brighouse, has kindly supplied the author with a solution of this same problem obtained by applying the graphical method referred to above. His corresponding results are 55,000 lb.-in. and 37,200 lb.-in. per inch respectively, being in each case slightly greater than the calculated value owing no doubt to the tendency noted above for the step-by-step construction to give high results. Both methods give exactly the same value $r = k = 21{\cdot}6$in. for the points at which the bending moment vanishes and changes sign.

Vancouver Harbour.

BOTH from a physical and a commercial point of view, Vancouver Harbour—Canada's great western outlet to the Pacific Ocean—has made wonderful strides in recent years. By improving its port facilities, by broadening its policies, and by attracting to its shores steamship lines of many countries, together with numerous industries, the product of Canadian, British, and foreign capital, Vancouver has firmly established its claim to being one of the most important harbours on the North American continent.

During the last few years many notable improvements have been made in the port facilities, but the two outstanding achievements have been the construction of the huge new Ballantyne pier at Burrard Inlet, and the erection of the Second Narrows bridge connecting the north and south shores of the central harbour where the port development of the next fifty years will be centralised.

The total area of Vancouver Harbour is 48·78 square miles ; the section west of the First Narrows is 20·20 square miles ; Burrard inlet, 13·84 square miles ; North Arm, 13·57 square miles ; and False Creek, 1·17 square miles ; and the total shore line is 98 miles. From its geographical position, the harbour is the Pacific terminus of the great Canadian transcontinental railway system, in addition to which there is a considerable business from the United States of the Great Western, Northern Pacific and Chicago, Milwaukee and St. Paul railways, all of which have connections with the port.

There is considerable tidal range at Vancouver, which is of rather an extraordinary and unusual character, and it was only after seven years' con-

* THE ENGINEER, September 23rd, 1904, p. 298.

tinuous observation, day and night, under the supervision of Dr. W. Bell Dawson, M.E.I.C., Superintendent of the Tidal and Current Survey Department of the Naval Service of Canada, that the actual levels of the tide were settled. At Vancouver and Victoria, as well as throughout the Strait of Georgia generally, the tide is of such a type that the springs and neaps do not appear. The tide levels inside the First Narrows vary about 4in. from those in English Bay. Extreme low tides occur only twice per annum, in June and again in December or January. The actual levels adopted for all work in Burrard inlet are as follows :—

Extreme high water	100·00
Higher high water (taken to be equivalent to high water ordinary spring tide, as referred to under the Dry Dock Act)	97·77
Average ordinary high water	96·25
Average ordinary low water and levels to which soundings are reduced	84·77
Extreme low water	83·45

BURRARD INLET.

In 1912 Andrew Don Swan, M.E.I.C., consulting engineer, Montreal, Quebec, was instructed by the Dominion Government to examine into and report on the general conditions and make such recommendations for the future development of the port of Vancouver as seemed to him most suitable to promote its growth, and otherwise best serve the interests of the port and of the country. Although there were many excellent sites for shipping facilities, Burrard inlet seemed to be the natural deep-water harbour for ocean shipping. Accordingly, the following recommendations were made :—

That the work of widening the First Narrows, so as to give a width of 1400ft. and a depth of 30ft. at low water, should be proceeded with, which meant about 2,000,000 cubic yards of dredging; that additional wharfage should be provided along the Vancouver city side of the inlet; that False Creek, which extended almost into the centre of the city, should be dredged to a depth of about 20ft. at low water, and used for coastwise traffic; and that the upper end of False Creek, extending to about 300 acres, which was then dry at low tide and covered with a few feet of water at high tide, should be entirely filled with material dredged from False Creek, and the land so reclaimed be used as a great central railway terminus, to which all the railways entering Vancouver should have access; that the north arm of the Fraser River, extending from the city of New Westminster to the Gulf of Georgia, a distance of about 17 miles and having a width of about 600ft., should be dredged so as to give a minimum of 10ft. depth at low tide; and that two training walls should be constructed at the mouth of the Fraser River to prevent siltation. The construction of a grain elevator of suitable capacity was also recommended.

At the same time, owing to the greater part of the foreshore rights near the city of Vancouver having been acquired by the railway companies, it was strongly urged that the harbour of Vancouver should be controlled by one board of administration, so as to permit of the systematic development of the port. Three alternative systems of port management were suggested :—First, that the harbour should be considered as a national port and taken over by the Government, and a local harbour commission be appointed, similar to that at the port of Montreal; or, secondly, that the harbour should be acquired by the city of Vancouver and be managed by a committee of the city council, as at Bristol, England; or, thirdly, that the harbour should be controlled as a port trust under the management of a board of representatives appointed by the various interests, such as the city of Vancouver, the railway companies, the shipping companies, the Board of Trade, &c., as at Liverpool, Glasgow, &c.

In accordance with the foregoing recommendation, the Government selected Scheme No. 1, and by Act of Parliament in May, 1913, the harbour was placed under the jurisdiction of a board of three harbour commissioners, "with powers to regulate and control by by-laws, navigation and all works and operations, and with other necessary powers for the proper development and administration of the port, and to impose rates, fees, and dues for revenue purposes." Nearly all the other recommendations in the report for the development of the port were given effect to, but owing to the war progress was somewhat delayed.

At the beginning of the year 1919, however, Mr. Swan was again instructed by the Government to make recommendations for the further development of Vancouver Harbour, and he found that, since his former report, the total import, export, and coastwise traffic had increased in the year 1917 by 164 per cent. over the year 1913. It was therefore recommended that a comprehensive scheme for wharf area, piers, railway termini, roads, sheds, warehouses and freight-handling facilities in general should be designed on a broad basis and constructed by degrees as required.

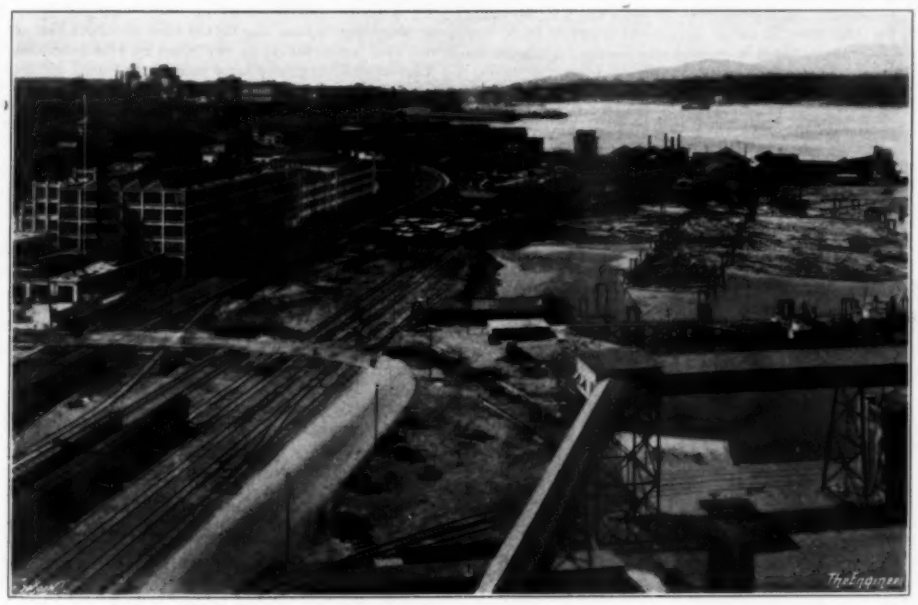
The question of deciding on a site for further immediate construction of new berthage required considerable time and investigation, and the Harbour Commissioners finally decided to proceed with the first large pier development at Burrard inlet, and Mr. Swan was instructed to recommend a suitable site on the main harbour front. In this connection, one of the most important features for study was the provision of the necessary railway connection so as to permit of all the railways entering Vancouver to have access to the projected new works. The Canadan Pacific Railway runs practically parallel with the south side of Burrard inlet, and consequently cuts off other railways from getting easy access thereto; in addition to which, a very large portion of the main harbour frontage nearest to the city, between the railway and the water, was owned outright by the Canadian Pacific Railway. Mr. Swan concluded that a harbour terminal railway, between the Canadian Pacific Railway and the water, should, if possible, be constructed by the Harbour Commissioners, and be operated by them.

At that time the Great Northern Railway had a single track line about a mile long, extending from what is now known as the Great Central Railway Terminal, built on land which previously had been a mosquito-infested swamp at the head of False Creek, and this branch railway crossed the main line of the Canadian Pacific Railway on the level near the Great Northern Railway pier. All the inward and outward cargoes to be handled at this section of the water front from all the different railway systems, both Canadian and American, entering Vancouver, with the exception of the Canadian Pacific Railway, were handled over this crossing, and therefore it was desirable to construct the first pier as near to this crossing as reasonably could be done, so as to avoid having to purchase any more foreshore land than was absolutely necessary to begin with, as the land was valued at about 1000 dollars per foot front. Mr. Swan therefore recommended that a site immediately west of the Great Northern Railway Company's existing pier should be selected, and a vacant frontage of about 960ft. was purchased. It was proposed that the Harbour Commissioners should either purchase or arrange running rights for their terminal railway over the Great Northern Railway spur line, as the site selected offered the shortest railway haul to the central terminus, and was also in close proximity to the present commercial centre of the city.

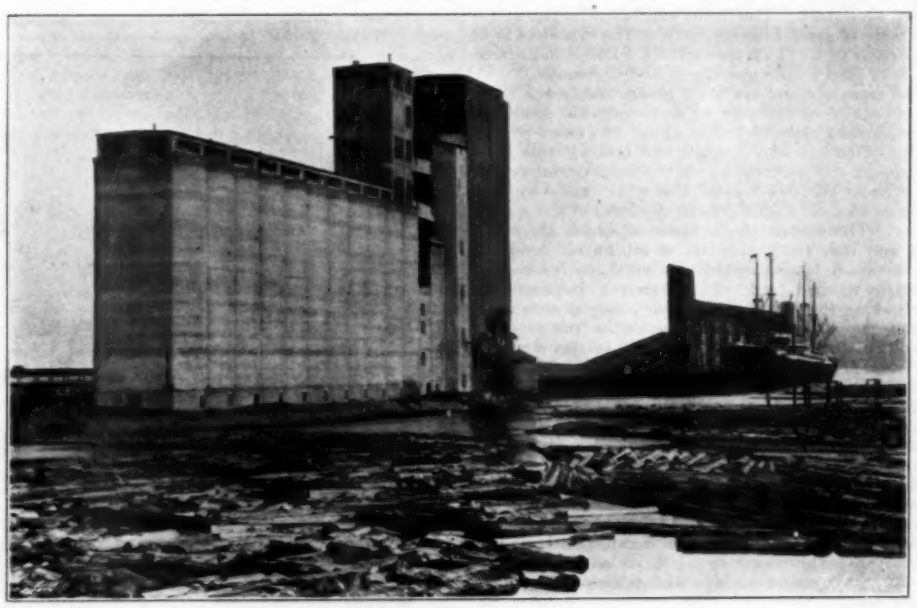
The substratum of the site being sandstone rock, offered a reasonably good foundation. The site selected also had the advantage that the adjoining site, belonging to the British Columbia Mills Company, was offered at a reasonable price, although not purchased, and it appeared that, if it was ultimately acquired for future development, the first pier would form one unit of a comprehensive consecutive scheme. The depth of water at a distance of about 1500ft. out from the shore was about 78ft. below low water level.

As the marine worm, *teredo navalis*, is very active in Vancouver Harbour, it was decided to use concrete in the construction of the new pier, although many of the other piers in the harbour are constructed of B.C. fir timber, which seems to stand the attack for at least ten to fifteen years. The water in Vancouver Harbour is less saline than in the Pacific Ocean, owing to the fact that it is diluted to a certain extent by fresh waters from rivers running into the inlet, and by the fresh water from the mighty Fraser River being carried back by the current into the harbour proper. The fresh water remains on the surface, owing to its lightness, and minimises any chance of deterioration of the concrete between high and low water.

It was found that there was very little difference in cost between a concrete pile pier with solid fill and a concrete cylinder pier with solid fill, and Mr. Swan therefore decided to recommend concrete cylinders as they would provide a more substantial structure than piles, and would be less liable to damage and deterioration. As finally designed the pier was 1200ft. long on one side, and 1075ft. on the other by a width



VIEW OF THE HARBOUR LOOKING WESTWARD

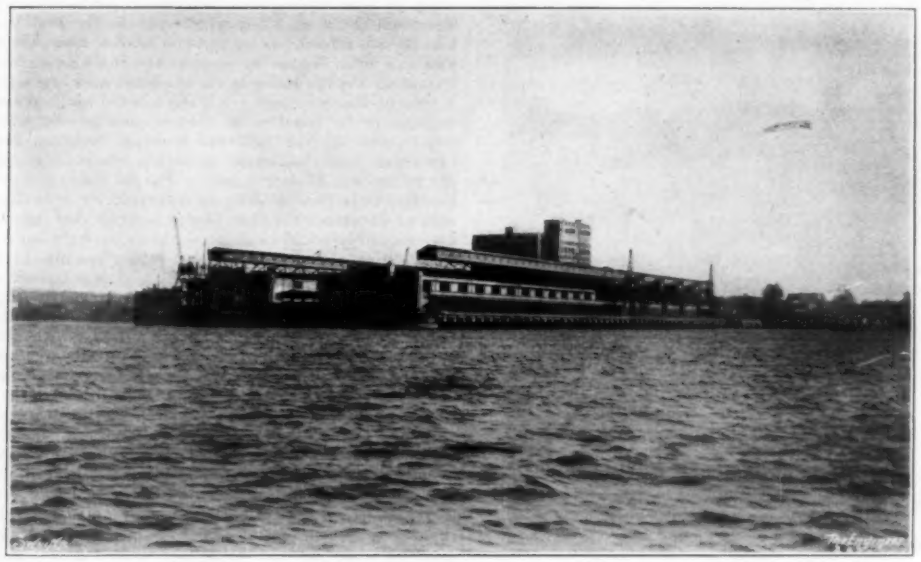


BURRARD GRAIN ELEVATOR AND JETTY

of 341ft., and there was, in addition, a shore quay of 350ft. in width.

Description of Ballantyne Pier.

The heart of the pier was formed of sand and gravel filling about 134ft. wide at the top, with sides sloping at about 1 to 2·4. At the inner berths the basins were dredged to a depth of 35ft., and at the outer berths there is a minimum depth of 45ft. below ordinary low water level. The floor or deck of the pier consists of reinforced concrete supported by pre-cast reinforced concrete trusses, which are carried on rows of reinforced concrete cylinders resting on



Ballantyne Pier

rock bottom. There are four rows of these cylinders at each side of the pier at the inner end and three rows at the outer.

The cylinders are 7ft. diameter outside, with a thickness of 9in., and there are altogether about 30,000 lineal feet or 5¾ miles in the piers, containing about 25,000 cubic yards of concrete. They were cast in lengths varying from 4ft. to 17½ft. In addition to the circular reinforcement, longitudinal rods, which projected at each end of the cylinder and were threaded so that various sections of the cylinder could be bolted together with nuts and clips, thus furnishing continuous steel reinforcement from top to bottom of any desired length were used. The forms employed for the cylinders were of steel; the concrete of the cylinders is in proportion of 1 : 1½ : 3 throughout. Particular attention was paid to the grading of the aggregate.

The transit sheds are built about 30ft. back from the cope line of the pier so as to provide space to accommodate railway tracks along the front of the sheds. There is also a single rail laid at cope level to support the vertical leg of the semi-portal cranes which span the two tracks, the other crane support being carried on a platform at the level of the second storey. The transit sheds, three of which are 500ft. long and one 400ft., are all of reinforced concrete, two storeys in height by 110ft. in width, with a loading platform at the back of the sheds. Between the sheds along the middle of the pier there is accommodation for three railway tracks and a roadway for vehicular traffic. The ground floor of the sheds at the front is at the same level as the cope of the pier, and is constructed on an easy gradient from the front to the back so as to obtain the requisite height to permit of direct loading into railway cars. The level of the tracks and roadways between the sheds is practically the same as that of the cope.

Mechanical equipment for handling cargoes is provided and consists of a number of semi-portal electrical cranes spanning the two railway tracks in front of the sheds and capable of handling cargo either to or from either floor of the sheds and the hold of the largest steamer afloat, whilst inside the sheds, motor trucks, electrical conveyors and elevators are provided for the rapid handling of cargo.

Contract No. 1.

The first contract let was for dredging the basins on both sides of the pier and for filling the shore quay and forming the hearting of the pier for about 1200ft. out. The quantities of material comprised in the dredging and filling contract were approximately 81,000 cubic yards of soft dredging consisting of mud, silt and sand, of which quantity about 12,000 cubic yards were used as fill, 86,000 cu. yds. of rock varying from a very soft sandstone to a very hard concrete-like conglomerate, and 615,000 cubic yards of filling, of which about 80,000 cubic yards were in the shore quay fill and the remainder in the pier hearting.

The rock dredging was carried out by two drills and two dipper dredges, the smaller one being principally engaged on the deeper outer portion of the work owing to its long dipper stick. The softer part of the rock was drilled with a special arrangement called a "bull drill." It was mounted on a pile driver and consisted of a timber casing which travelled in guides in the leads of the pile driver, and which was lowered until it rested on the bottom. Inside this casing there was a long steel drill about 3in. in diameter, the lower end being of drill steel welded to the shaft. The upper end of the drill was enlarged, and below the enlargement was a loose collar which was attached by means of two short chains to the ordinary pile driver hammer above it in such manner that there was about 3ft. between the hammer and the top of the drill when the chains were tight.

In operation, the hammer was lifted and took with it the drill to the full extent of the chains. The whole arrangement was lifted clear of the bottom and then dropped, and after the drill struck bottom the hammer followed, striking a blow on the drill as in driving a pile. The drill and hammer were then lifted again, and the process repeated. The effect was that the drill was driven in the same way as a pile except that after every blow it was lifted in the hole and thus prevented from jamming. The arrangement was very cheap to operate, and, in practice, could rapidly put down holes from 8ft. to 10ft. deep in the soft rock. The holes were loaded and fired in the usual manner. These drills were not capable of dealing with the harder portions of the rock, and for that work two single steam drills, also operated from the pile drivers were used. The spacing of the holes varied from about 7ft. to 3ft. centres, according to the nature of the rock, and generally the work was carried out in three lifts.

The filling was dredged from the neighbourhood of the Second Narrows by the larger dipper dredge, fitted with a six cubic yard bucket for the purpose, and transported to the pier, a distance of about 2½ miles, in dump scows. The material consisted of a coarse clean gravel varying in size from sand to small boulders about half a cubic foot in volume. This material stands permanently at a slope of about 1 to 2·4 under water.

The elevation of the top of the pier hearting is 4ft. above high water. The bulk of the material for this hearting was dumped in place by the scows which, making use of the tides, brought it to about 3ft. above low water. Above this level the bank was built up by two clamshell dredgers, working one on each side of the bank, and lifting material from the toe of the fill at the outer end and depositing it on the bank behind. The shore quay fill, carried to a height of 7ft. above high water, was in too shallow water to permit of any of it being dumped direct, and consequently a bank was thrown up at the seaward face of the fill by the clamshells, and the area behind filled in by a suction dredger which took material from the pier hearting before the latter had reached low water level, this material being replaced by the dump scows.

The entire contract was completed and all claims settled for about one thousand dollars less than the original tender, which totalled 513,121 dollars.

Contract No. 2.

The second contract included the whole of the concrete work of the pier and a short piece of the shore quay wall, and the construction of the two-storey reinforced concrete sheds with paved roadways, railways and trackage. The first work undertaken was the pre-casting of the concrete cylinders, and for that purpose the contractors leased about 30 acres of level filled land at North Vancouver, about two and a-half miles across Burrard inlet from the site of the works. The general lay-out of the yard was such that the sand, gravel and cement were all delivered by water, this material being handled from the scows by means of a travelling timber gantry crane operating a one-yard clamshell bucket, which delivered either direct to bins over the mixer or to storage on either side.

The mixing plant consisted of overhead bins which delivered into measuring boxes and thence into the hopper of a one-yard Smith mixer, which discharged into buckets on cars. A 20-ton stiff-leg derrick crane was used for the cylinder fabrication, the cylinders being arranged around it in the form of a circle. The concrete for the trusses, piles, beams, &c., was distributed in conical buckets, the trains carrying the latter running on standard gauge tracks, hauled by a gas locomotive. The concrete was delivered direct from the mixer to the cylinder forms by derrick, which was also used to set up and take down the steel forms, reinforcement and steaming tarpaulins, as well as to handle the concrete cylinders and load them on cars for removal to the skidways.

In commencing the construction of the cylinders, tamping of the concrete in the usual manner by hand was adopted, but it was soon altered to tamping by two small air hammers which vibrated the outer steel shell of the form while the concrete was being poured. This was found to produce a more dense mass with a better skin than that obtained by hand tamping. Steam curing was resorted to so as to enable the forms

General View of the Harbour

to be removed and sections handled as soon as possible after the concrete was poured. Steam was turned on through two jets, one on the inside and one on the outside of each cylinder after the forms were filled and covered over with a canvas tarpaulin something in the nature of a tent. The cylinders were steamed for four hours, after which the covers were removed and the forms stiffened. In cold weather the steaming covers were replaced and an additional four-hours steaming given. Four days after pouring, the cylinder sections were placed on a car operating on a depressed track, so that the floor of the car was level with the skidway, and the cylinder sections were rolled on to the skidways where they lay during the curing or hardening process for from two to three months before

being used in the pier. The trusses, fender blocks, struts, sheet piles and walings, &c., were cast on platforms surfaced with sheet iron inside sectional wood forms lined with steel, and the steel reinforcing rods were left projecting beyond the concrete in the units so as to tie them properly together and form a bond in the completed structure. The trusses were cast four-high, one on top of the other, so as to save space, a wooden form covered with sheet steel being placed between each truss. All the steel for the reinforcing steel cages and other parts was bent by a large motor-driven power bender.

SINKING CYLINDER PIERS.

The cylinder piers, of which there are 413 in the pier proper and 57 additional in the shore quay, consisting of precast sections bolted together, were placed in position and eventually sunk by the use of specially constructed cylinder drivers carried on timber falsework or staging. The sections of the cylinders when loaded up at the yard were towed across the inlet on scows and lifted therefrom by a floating derrick, and built up in the lead of the driver as the cylinder was forced down through the material to bed rock or to suitable foundation. The drivers were capable of handling sections of cylinder bolted together weighing up to 85 tons.

In many instances, as the cylinder drivers were the only machines available to set the cylinders, after the cylinder had been sunk to a considerable distance, the driver was moved to another cylinder and sinking operations were completed by a skid derrick. This permitted of more rapid and expeditious work of the drivers, of which there were five. As the cylinder sank, the material was excavated from the inside with orange peel buckets in the usual way, and 6-ton and 12-ton special cast iron rings were used as kentledge when necessary to overcome friction. In some cases 240 tons additional weight was added to the cylinder giving a skin friction of about 375 lb. per square foot. High-pressure water jets were used where the material encountered by the cutting edge could not be excavated by the orange peel.

The maximum applied load on any cylinder was 500 tons, and the unit pressure allowed on the hard conglomerate was about 14 tons per square foot, and on the softer conglomerate and sandstone about 8 tons per square foot. The cylinders were built up in the lead of the driver by the floating derrick placing a length of cylinder on the top of the cutting edge section so that the joint could be waterproof and the two sections bolted tightly together, and this operation was repeated with each section as the sinking process continued until the top of the cylinder was about high water level. When the necessary lengths were all in place and connected, an additional 15ft. length was added without the joint being waterproof, in order to give increased weight and also to permit of the material from the orange peel bucket being discharged free from the actual completed cylinder; this 15ft. top length was afterwards unbolted and used in a similar manner on subsequent piers.

When the cylinder was finally sunk to a suitable foundation and approved by the resident engineer, who had to make all examinations inside these cylinders in a diving dress, the loose material inside the cylinder was cleaned out by a diver and a seal of rich concrete, generally deposited by underwater concrete buckets, provided. When the seal had sufficiently set the top weight section of cylinder was unbolted and a wooden stave cofferdam was placed on top of the cylinder so as to bring it well above high water mark; the cylinder was then pumped dry, cleaned and inspected, and finally filled with mass concrete in proportion of either 1 : 3 : 6 or 1 : 4 : 8 up to a level of a little above low water mark. Then followed the work of setting the reinforced concrete trusses on the top of the filled cylinders, and of constructing the main deck of the pier.

CONSTRUCTION OF THE SHEDS.

The two-storey transit sheds, four in number, are entirely of reinforced concrete with certain brick panelling. The principal forms were made of steel, so as to permit of speedy erection and stripping, and the forms for the main girders of the first floor were carried on steel trusses. The main columns were constructed of 1 : 1½ : 3 concrete, whilst a 1 : 2 : 4 mix was used for the remainder of the sheds.

The ground floor of the transit sheds is covered with a bituminous mixture called Asbestophalt, which consists of a mixture of 14 per cent. bitumen, 8 per cent. carded asbestos, and 78 per cent. of sand carefully graded between a No. 8 mesh and a No. 200 mesh screen. The whole was mixed mechanically at a temperature of 300 deg. Fah., and conveyed in motor trucks to the work from a central mixing plant in the city. It was spread so as to give a thickness of 1in. when thoroughly rolled, and was capable of carrying traffic as soon as it had cooled. This material had not been used to any extent before in Canada, but before deciding to use it in the sheds, a small area was laid in one of the busiest streets in Vancouver, and observations extending over several months gave very satisfactory results. The quay space in front of the sheds between the rails was covered with bitulithic paving. On completion the interior of the sheds was finished with two coats of cold water paint, consisting of 7 per cent. glue, 10 per cent. china clay, 83 per cent. best air-floated English whiting, put on by sprays.

ELECTRICAL SUPPLY.

The whole of the cranes, transporters, elevators, and other cargo handling facilities are all electrically driven. The current is supplied from outside the property by the British Columbia Electric Company, the current being 2300 volts, three-phase for service, transformed to 115–250 volts, single phase for lighting, and 550 volts, three-phase for power. The transformer-room and switchboard-room are situated in the corner of shed No. 4. The C. H. E. Williams Company, Ltd., undertook the electrical contracts, and supplied approximately 20 miles of conduits, 90 miles of insulated wire and 1¼ mile of trolley wire.

Each of the sheds is equipped with one electric freight elevator. The purpose of these elevators is to transfer electric or other types of small trucks from the one floor to the other. The freight elevators were designed to handle a maximum load of 18,000 lb., with cars 18ft. by 12ft., large enough to permit electric or petrol freight trucks and trailers to be run on and off. In order to avoid the use of a penthouse projecting above the ordinary level of the shed roofs, the cables are anchored to dead men on the upper floor, and pass on sheaves underneath the car to the elevator machine, also on the upper floor, but on the opposite side to the anchorages, so that the car practically rests in the slack of the main cables between the anchorages and the machine. The counterweights travel inside the shaft and their cables pass over sheaves which are arranged just beneath the shed roof. These elevators are driven by 35 H.P., squirrel-cage induction motors.

One escalator is provided in each shed to transfer general freight from the pier deck floor to the upper floor. These escalators are capable of handling packages about 5ft. in width and up to 1000 lb. in weight, at 60ft. per minute speed. Each is operated by a 1½ H.P. Lancashire motor placed on the first floor of the sheds.

A number of electric capstans of the usual type has been provided in different positions for hauling railway cars when necessary.

Views of the Harbour and the new works are given herewith.

Institution of Mechanical Engineers.

ON Friday of last week, Mr. E. G. Herbert presented before the Institution of Mechanical Engineers a "Report on Machinability," prepared for the Institution's Cutting Tools Research Committee. A lengthy abstract of this report will be found reprinted elsewhere in this issue.

In moving a vote of thanks to Mr. Herbert, the President, Mr. Richard W. Allen, commented adversely on the qualities of the so-called "free-cutting" steels. The introduction of these steels into general engineering was, he said, one of the saddest things which had occurred since the war. As engineers, we should study the after effects obtained by the use of certain materials and not sacrifice good subsequent behaviour on the part of our products for facilities conferred on production.

Dr. W. Rosenhain, called upon to open the discussion, said that with Mr. Herbert's main conclusion, namely, that the initial hardness of a metal provided no measure of its machinability, he was in agreement, but he could not agree that the initial hardness was quite so much without effect as the author implied. Mr. Herbert seemed to contradict himself on the point. He stated in the paper that if a Pendulum work-hardening test were made on metal which had already been work hardened by any previous treatment, the resulting hardness figures were always higher than those obtained on the same metal in its original, non-work-hardened state. It would therefore appear that the machinability of a metal must in some measure depend upon the extent to which the metal had previously been work-hardened. The hardness which existed at the cutting point was in some degree determined by the initial hardness of the metal. It had been shown that hardness obtained by cold working increased the machinability of a metal, whereas hardness obtained metallurgically decreased it. Mr. Herbert's "Law of Machinability" seemed to him to involve a contradiction of terms. Machinability, he maintained, was a property of the material and not of the material in association with the cutting tool. The law was, however, valuable in that it provided a criterion whereby to judge the efficiency of tools of different shapes. That tool was best which produced the lowest hardness in the chips. Discussing the appearance of what Mr. Herbert suggested might be slip bands in his chip specimens of manganese steel after they had been polished, Dr. Rosenhain remarked that he thought the lines really did represent slip bands. He did not, however, think with Mr. Herbert that it was a case of the release of internal stress after the specimens had been polished. He believed that the bands represented a Martinsitic transformation accompanying the slipping which took place during the actual cutting of the specimens Such transformation would be revealed by the differential effect of the etching and polishing processes on the traces of the planes of slip. The "ageing" of steel after deformation was a factor which had to be borne in mind in discussing Mr. Herbert's results. The initial hardness of the metal did not exist in front of the cutting tool. Neither did the hardness which Mr. Herbert measured on his chip specimens, for by the time he measured it ageing and hardening had occurred.

Mr. William Taylor said that the cuts taken by Mr. Herbert in his lathe experiments were relatively heavy. His own interests lay more with the thinner cuts taken in the hack saw experiments. He noted that when Mr. Herbert reduced the thickness of the chip he still obtained a built-up edge. His own experience contradicted that result. With thin chips he found no built-up edge. At slow speeds Mr. Herbert stated that the built-up edge disappeared. That was an interesting result in view of the discussion which arose on the reading of the paper by Dr. Rosenhain and Mr. Sturney before the Institution in 1925. It was disputed whether the built-up edge and the crack preceding the point of the tool always were present. Sir John Dewrance subsequently carried out some experiments on the reaming of holes in phosphor bronze. These experiments appeared to show that the holes were always larger than the reamer. In his own experience, however, holes were sometimes smaller than the reamer. That phenomenon was no doubt due to the absence of the built-up edge at low speeds. It provided justification for the practice of using hand reamers at low speeds after machine reaming had been carried out. Turning to another part of the paper, he desired to know why the chips produced at low speeds were broken into fragments and showed a higher hardness than chips of the same metal produced at higher speeds. Was it because at the higher speeds the chips were heated to a higher temperature and were therefore more easily bent out of the way of the tool? In one of his experiments Mr. Herbert showed that the hardness of the chip diminished towards its centre line. Was not that explained by the fact that the centre contained the neutral axis where the stresses were least? Discussing the anomalous results given by cast iron, he said that cast iron could be hardened by allowing the tool to slip over the surface without cutting. That fact was well known to the turner in the shops. The tool had to be caused to "cut the skin" of the metal or the metal would harden. The property involved was a very valuable feature of cast iron. It led, for example, in the manufacture of sewing machines, to the practice of skin hardening the surfaces of holes by driving a corrugated drift through them. The compression produced was of the order of two or three ten-thousandths of an inch, and not only produced increased hardness, but promoted accuracy in the size of the holes.

Sir Henry Fowler remarked that if there were any weakness in the paper he felt it lay in the adoption of a uniform cutting speed. He would like to know what was the state of the surfaces cut at the standard speed. From the photomicrographs it appeared to have varied very considerably. In the shops the object was to run the machines at the highest possible speed consistent with the attainment of the desired surface finish on the work. What, he asked, was toughness in a metal? He would like to have a definition of it from the cutting standpoint. Mr. Herbert, he thought, need not worry about the anomalies presented by cast iron. It was obvious to all who had ever handled it in a machine that it was an exceptional material.

Mr. Rolfe, discussing the properties of "free cutting" steel, said that there were enormous differences in the rates at which it could be cut relatively to ordinary mild steel. Those differences were due to its greater brittleness induced by the presence in it of phosphorus, manganese and sulphur, which broke up the continuity of the metal just as carbon broke up the continuity of cast iron. It could be cut at about three times the speed of ordinary tough mild steel. The cast iron chip did not harden, probably because of the readiness with which the carbon caused the chip to break up. Mr. Herbert's experiments with "compound" tools were, he thought, likely to prove of great value in the workshop.

Mr. Pendred desired to know whether the saw used by Mr. Herbert in his hack saw experiments varied in hardness after the successive grindings between each pair of tests. What effect, he asked, would the absence of a cooling medium have on the self-hardening properties of the metals cut? He agreed with Mr. Taylor that in Mr. Herbert's experiments the action of the tool was slightly different at the re-entrant corner of the cut from what it was at the external angle. In order to overcome that "cornering" effect Mr. Herbert himself had a number of years ago devised a tool testing machine in which the specimen took the form of a tube, the tool being made to cut across the full thickness of the tube by means of a feed applied parallel with the tubular axis. Why had Mr. Herbert departed from that system?

Mr. Herbert, in his reply, agreed with the President regarding the poor quality of free-cutting steel from all standpoints except that of the ease with which it could be machined. It was sometimes used when it should not be employed, for it was a very treacherous material. Passing to Dr. Rosenhain's remarks, he said that he had never found a crack preceding the point of the tool except just at the start of the cut. Afterwards the built-up edge was formed and seemed

to fill up the crack that otherwise might be present. He agreed that the work-hardening capacity shown by the Pendulum test did not show the maximum work hardening of which the metal was capable. A piece of metal work hardened by being reduced by hammering to 1 per cent. of its original thickness showed a higher hardness than the maximum recorded during a Pendulum work-hardening test. At less severe reductions, however, the hardness of the hammered metal was less than the Pendulum maximum. Concerning the machinability of cold-worked material he had no data, as all his tests were carried out on bars previously heat treated. Dr. Rosenhain had said that machinability was a property of the metal and not of the machining process. It was, however, a fact that two metals would reverse their order of machinability when the tests were transferred from one machine to another. Which order was the right one to select, and what practical means could be adopted for the elimination of the undoubted machine effect? In an investigation of the kind he had undertaken it was most desirable to reduce the list of variables to the lowest possible number. For that reason he had standardised the cutting speed and the shape of the tool. He agreed, however, that neither the speed nor the tool used was the best for all the metals tested. He could assure Mr. Taylor that on the standard tool tester referred to by Mr. Pendred a very definite built-up edge was formed even when the feed was as light as one-thousandth of an inch. The appearance of the finished surface of the work could not be judged, as Sir Henry Fowler seemed to think, from the photomicrographs. The surface of the work shown was that of the radial plane face against which the tool worked and not the cylindrical surface of the turned bar. He did not think that the heating and bending of the chips to which Mr. Taylor referred could enter into the problem, for in all his experiments the work was cooled by a copious supply of lubricant. He agreed, however, with Mr. Taylor's suggestion regarding the neutral axis of the chip and its effect on diminishing the chip hardness from the surface inwards. He could not supply Sir Henry Fowler with a definition of toughness. Mr. Rolfe's explanation of the behaviour of free-cutting steel seemed to be in agreement with the steel makers' understanding of the subject, because the difference between free and non-free-cutting steels was usually expressed in terms of Izod values. He, however, had failed to detect any difference in their cutting properties.

Mercury Vapour Rectifiers at Shoreditch.

WHEN the glass bulb rectifier was first introduced few imagined that it would ever prove suitable for rectifying alternating current on a large scale. To-day, however, quite a number of these rectifiers are operating on public supply systems. Engineers who have adopted them seem to be quite satisfied with the results, which have apparently met all expectations.

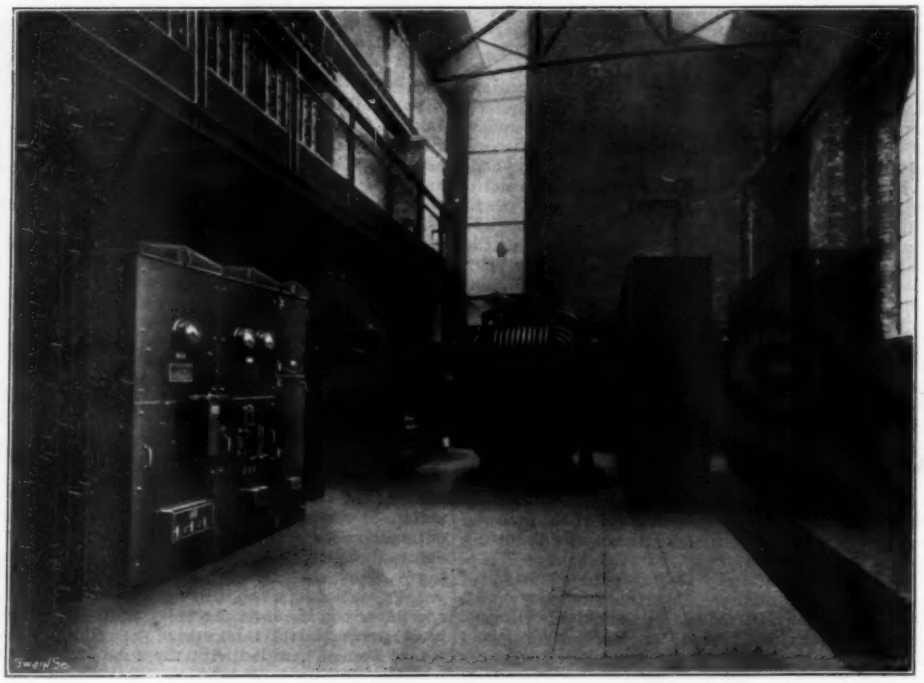


FIG. 1—PART OF SHOREDITCH SUB-STATION

To say that these rectifiers are rapidly replacing rotary converters and motor converters would scarcely be true, but the fact remains that we have met engineers who much prefer this static apparatus to rotary machinery. There are, of course, conditions under which rectifiers cannot be employed, as, for example, when it is desired to reverse the converting process and obtain alternating current from direct current. Again, the rectifier has no power factor correcting property, like that of a rotary converter or synchronous motor generator set. Nevertheless, when it is merely a question of turning alternating current into direct current glass bulb rectifier equipments often have much to recommend them, and are indispensable in places where heavy rotating machinery is not permissible. Automatic and semi-automatic control gear for rectifiers is relatively simple and easy to understand, a feature that appeals very strongly to those who dislike complication. In places where the periodicity is likely to be changed rectifiers would appear to be very desirable, as periodicity makes no difference to their operation.

In the days when glass bulb mercury vapour rectifiers could only be made for small currents their use on public supply systems was out of the question, but within the last seven years or so the output of individual bulbs has been increased very considerably. In the year 1920 the current rating of the largest bulb operating at 550 volts direct-current was 30 ampères; in 1923, 150 ampères; and in 1927, 225 ampères. Operating at 250 volts direct-current the equivalent figures were 40 ampères, 200 ampères and 260 ampères, all these figures allowing for 25 per cent. overload of two hours' duration. The number of bulbs fed from one transformer has also been increased, and to-day there is no limit to the number that can be fed in this way. Another respect in which modern rectifier installations differ considerably from the original equipments is in the method of voltage regulation, which is now generally obtained by means of induction regulators which are more simple than the regulators used previously. Glass bulb mercury vapour rectifier sub-stations play an important part in the supply of electricity in the outlying districts of Birmingham; they are now employed extensively throughout the country on all types of loads and in varying capacity units. The largest individual sub-stations have been installed in London, the City of London Supply Company having one 2000-kW rectifier sub-station, which was erected in 1925, and another 2250-kW sub-station is at the moment being built, whilst the Borough of Shoreditch Electricity Supply Department has a rectifier sub-station at Evelyn-street which is already of 3700 kW capacity. The latter sub-station—shown in Fig. 1—originated in 1925 with a 600-kW rectifier equipment arranged to be increased to 900 kW at a later date. This installation was placed in what is now the wing of the present sub-station building, for in order to increase the growing demands it was decided to increase the capacity of the sub-station and a new building was erected for that purpose. As it was expected that about 6000 kW of plant would eventually be required, it was decided to increase the original bank up to 900 kW and to design the new sub-station to take four 1400-kW equipments. The station is now the largest glass bulb mercury vapour rectifier sub-station in the world.

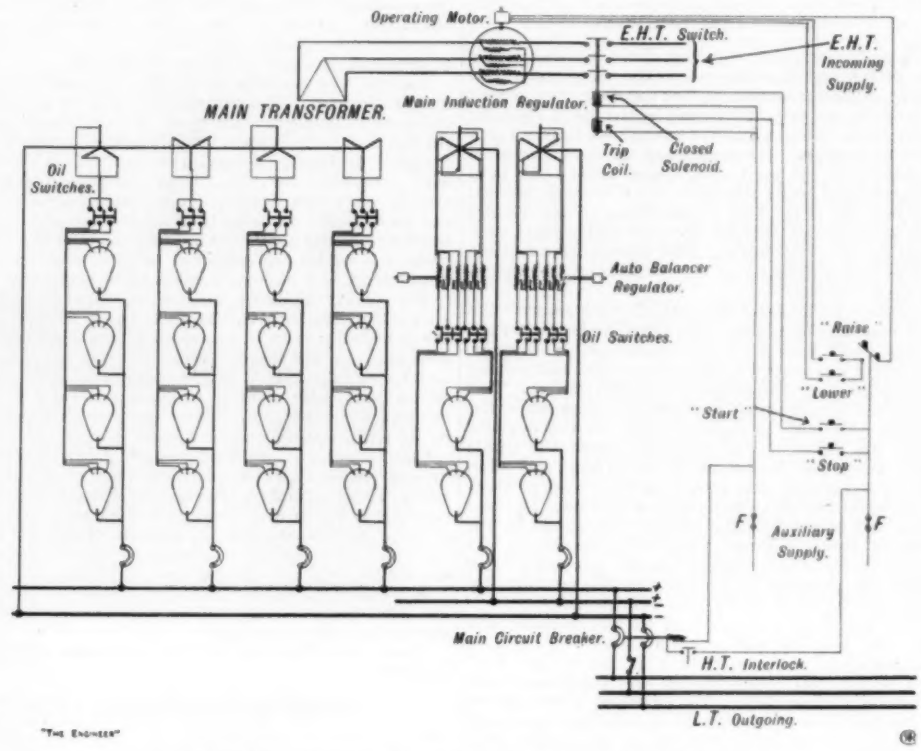


FIG. 2—SIMPLIFIED DIAGRAM OF RECTIFIER CONNECTIONS

When the original sets were ordered these rectifiers were more or less in their infancy. Their advantage from the points of view of simplicity and control were self-evident, but a certain amount of doubt was naturally entertained regarding the life of the bulbs. Up to the present, however, it has not been necessary to change a single bulb, and the original plant has proved entirely satisfactory in all respects. Two 1400-kW sets, one of which is shown in Fig. 1, have now been installed and they are arranged to feed into the 250–500-volt three-wire lighting and power network. The rectifiers are fed from a 6600-volt three-phase 50-cycle supply and operate in parallel with the original rectifier equipment in the same sub-station, as well as the other types of converting plant consisting of rotary converters and motor converters feeding into the system at other points.

The extra high-tension switchgear which was supplied by the General Electric Company is composed of three units, which control the incoming feeder, the rectifier equipment and a potential transformer unit. All the switches are designed for 11,000 volts and for a rupturing capacity of 100,000 kVA. They are operated by alternating-current motors and the operating circuits are fed from the potential transformer unit. The lay-out of the sub-station will allow the extra high-tension board to be extended with similar units for the control of additional converting equipments and extra high-tension feeders. The alternating-current panels which control the output from the rectifiers were supplied by Bertram Thomas.

It is well known that with mercury arc rectifiers the higher the direct-current pressure at which they operate the higher is the overall efficiency and the lower the cost, as a greater kilowatt output can be obtained from a bulb. When feeding a three-wire system with rectifiers it is therefore desirable to connect as much of the equipment as possible across the outers, as shown in Fig. 2, and to supply the inner conductors with the out-of-balance current by two six-phase windings which supply the rectifier bulb groups which feed into the inners of the three-wire system.

A 6600-volt three-phase induction regulator to be seen in the diagram controls the primary supply to the main transformer and consequently regulates the direct-current voltage, whilst another induction regulator, made up of two six-phase components, controls the supply from the secondary of the transformer into the balancer rectifier units so that the direct-current voltages on each side of the middle wire can be maintained equal under all conditions of out-of-balance current. The induction regulators were supplied by Switchgear and Cowans, Ltd. They are operated by motors under the control of pressure relays which tend to keep the pressure across the outers and on each side of the mid-wire constant at all loads and under all conditions of out-of-balance current and despite any abnormal fluctuations on the extra high-tension supply. Breakers of the auto-reclose type open in the event of severe overloads, and at times of short circuits, and automatically close as soon as normal conditions are restored on the network. They also open when the rectifier equipment is shut down on the extra high-tension side, and connect the equipment to the bus-bars as soon as it starts to rectify as the result of being made alive on the primary side. The pressure control circuits are taken care of by a master load-limiting device which prevents the direct-current pressure being raised when the full load is reached and causes the pressure to be reduced in the event of an overload, so that the equipment cannot deal with more than its proper share of the load, the pressure and load settings of the automatic gear being adjustable.

At the generating station at Cornet-street there is a push-button control panel for controlling the sub-station through pilot wires, and there are also instruments which show how much load the sub-station is carrying. By means of push buttons marked "On" and "Off" the equipment can be put into operation or shut down and the action of these control buttons is translated *vid* pilots to a single contactor at the sub-station, and this contactor closes the motor circuit of the extra high-tension switch, the closing of which is all that is necessary to put the rectifiers into operation. Another set of control push buttons controls the pressure relays and enables the pressure or load to be regulated at will. The illustration Fig. 6 gives a view of the automatic control panel in the sub-station. The direct-current automatic breaker panel is to be seen on the left, whilst the instrument panel, the push button control panel and the fully automatic relay control panel are to be seen on the right.

FIG. 3—DOUBLE-TIER RECTIFIER CUBICLES

smaller rectifier banks, as shown. Accordingly, at Shoreditch the 1400-kW equipments are made up of sixteen 75-kW bulbs with a total capacity of 1200 kW feeding across the outers and four 50-kW bulbs arranged in two groups feeding into the inner conductors. The bulbs are placed in double-tier cubicles—see Fig. 3—and each group is provided with independent low-tension alternating-current and direct-current isolating switchgear. The first bank of rectifiers installed in the Evelyn sub-station is shown in Fig. 4, whilst Fig. 5 shows the control cubicles containing the coils and isolating switchgear for operating the rectifier bulbs shown in Fig. 3. The main transformers associated with the two 1400-kW equipments and those for the earlier rectifiers were manufactured by the Hackbridge Electric Construction Company. As shown in the diagram Fig. 2, which relates to the 1400-kW equipments, the primary winding is delta-connected and the secondary

FIG. 4—EARLY BANK OF RECTIFIERS

consists of twelve-phase zigzag windings which feed the rectifier bulbs connected across the outers in the manner shown on the left of Fig. 2. There are also

FIG. 5—CONTROL CUBICLES

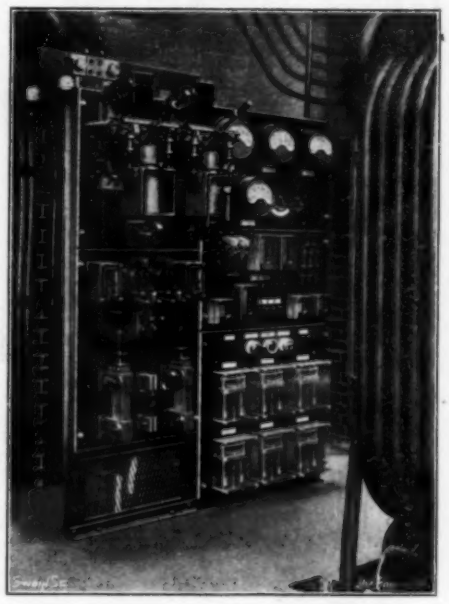


FIG. 6—AUTOMATIC CONTROL PANEL

Three-Cylinder Narrow-Gauge Locomotives for Colombia.

IN our annual review, "Locomotives of 1927," in THE ENGINEER of January 6th, 1927, mention was made of some three-cylinder locomotives put into service during 1927 on one of the Government railways of Colombia, South America. We are now able to give particulars of these engines, which in respect of certain important features are quite novel.

The locomotives are of the 4–6–2 type for main line service, weigh 56¼ tons in working order, and are constructed for the 3ft. gauge. They were designed at the end of 1925 by Mr. P. C. Dewhurst, M.I. Mech. E., Chief Mechanical Engineer to the Government of Colombia, and two were completed in 1927, one by the Berliner Maschinenfabrik A.-G., of Wildau, Germany, and one by the Forges, Usines et Fonderies de Haine-St.-Pièrre, Belgium. They have now been in service on the Pacific Railway for nearly one and a half years, thus being amongst the earliest three-cylinder narrow-gauge main line locomotives and being the first three-cylinder engines for the 3ft. gauge. They have proved so successful that a number of engines of similar design but larger, and of 4–8–2 type, are now being constructed.

The engines under notice are, we believe, the first locomotives with outside and inside cylinders combined with outside main frames only, thus forming perhaps one of the most striking changes in the fundamental design of locomotives which has been made for some years. The advantage of the system in allowing extreme development of power in relation to the rail gauge on narrow-gauge lines—and even on other lines where the proportion of loading gauge to rail gauge will allow—is evident, and it may be added that it also permits the use of two large inside cylinders in conditions not otherwise obtainable, thus providing a possible solution for difficult cases of compounding on standard-gauge locomotives.

These first two locomotives, although designed by Mr. Dewhurst and built according to his specifications and instructions, have certain differences—arranged in order to put to practical test certain details of design—and also some variations from the accompanying diagram representing the general design of the class as finally determined in the light of the practical results obtained in service. The differences are only in minor dimensions and details.

The B.M.A.G. engine is slightly lighter than the Haine St. Pierre, but has rather more heating surface with a higher proportion of superheat. Whilst in the former the necessary room for the inside cylinder has been obtained by flattening the base of the standard Colombian pattern smoke-box, in the latter it has been obtained by using a smoke-box of the same diameter as the front ring of the boiler barrel and allowing the upper parts of the exhaust passages to pass into the smoke-box. In the B.M.A.G. engine the inside valve is operated from a return crank on the right side crank pin of the rear coupled axle by means of a rocking shaft and connections to an inside link on the same centre line as the outside links, the lead being

obtained from the inside crosshead in the usual way. In the Haine-St.-Pièrre engine a modified form of the Holcroft-Gresley gear is employed with the horizontal floating levers placed behind the cylinders and connected to the outside valve spindle crossheads. The different arrangements of gear for operating the inside valve are due to Mr. Dewhurst, but their details were elaborated by the builders. In the case of the Haine-St.-Pièrre engine adjustable spherical bearings have been introduced in the articulations by Monsieur A. Weber, the Chief Engineer to the builders.

The locomotive constructed by the B.M.A.G. is shown in Figs. 1, 2 and 3. In the former the return crank on the rear coupled axle is clearly seen, and in Fig. 3, which shows the inside cylinder and valve chamber under the flattened smoke-box. The Haine-St.-Pièrre locomotive is shown in Fig. 4.

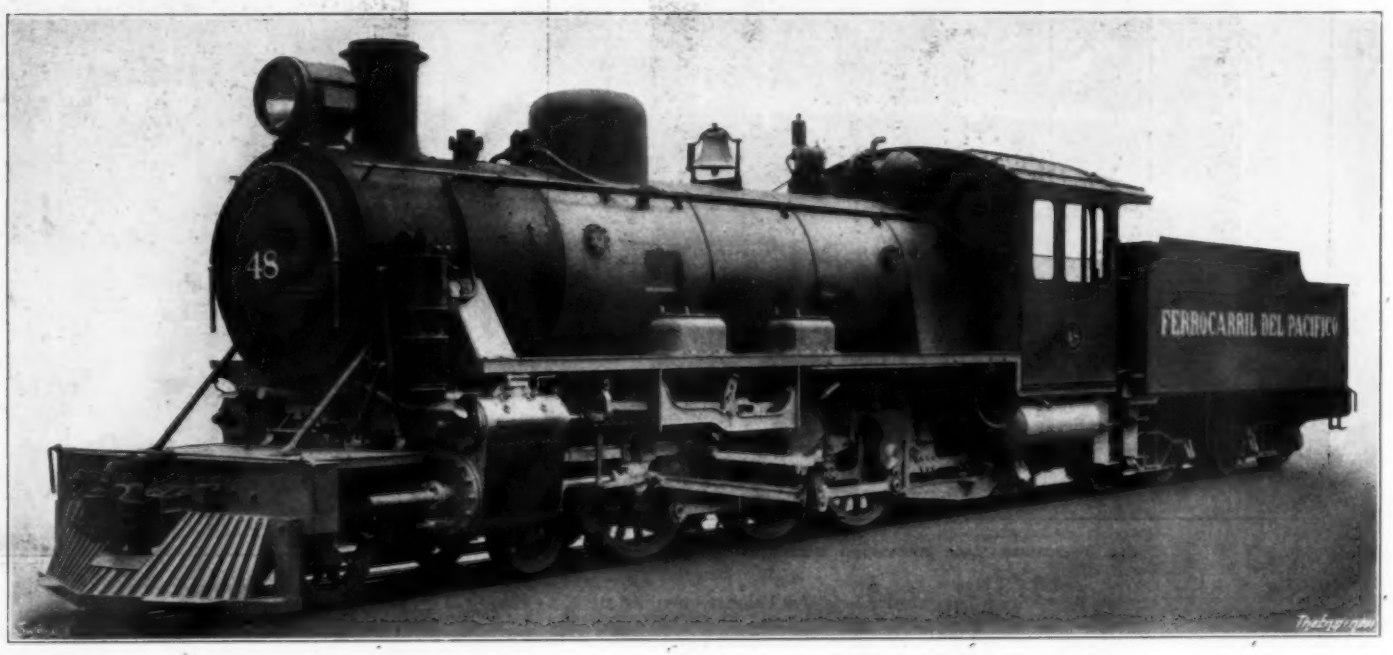
The advantage of the disposition of the main frames—with its many rivets and connections and indirect frame stresses.

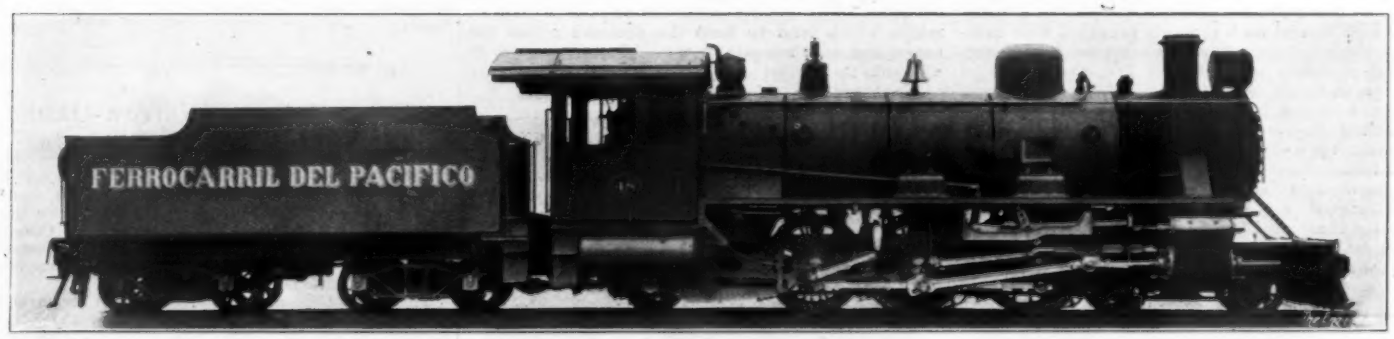
Fig. 5, which gives a half-section at the fire-box and a rear view of the foot-plate and cab, shows the relation of the outside framing to the fire-box, characteristic of Colombian standard designs. The roominess of the cab, practically the full width of the loading gauge, and the doors leading directly forward on to the running-plate will also be observed.

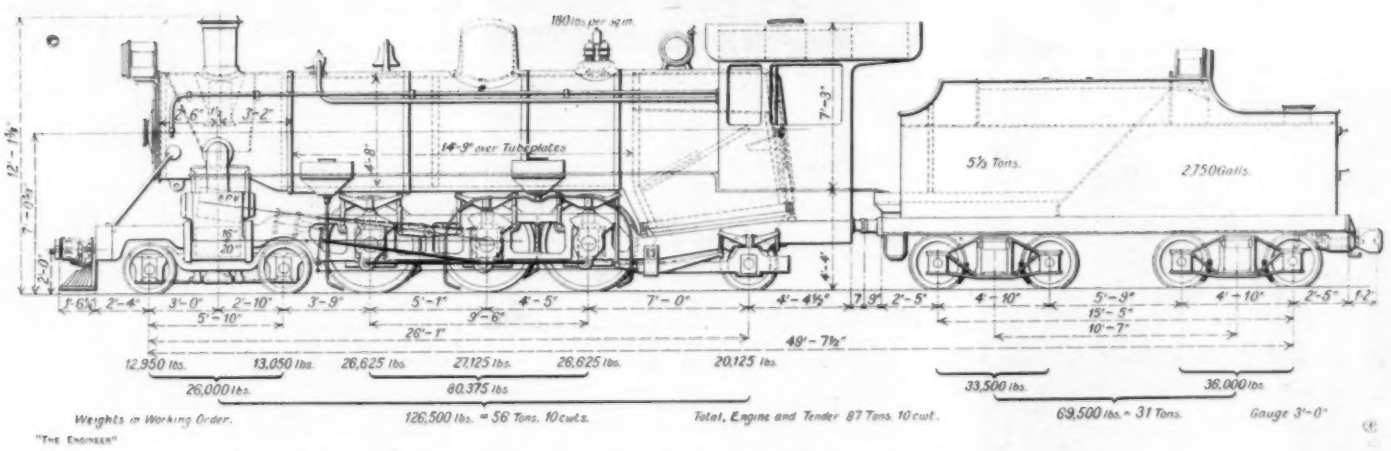
By means of the distribution of coupled wheel base adopted and the special arrangements at the base of the smoke-box, combined with the fixing of the theoretical centre to which the cylinder lines are directed at 2in. above the nominal centre of the driving axle, it has been possible to obviate the use of a bend or crank in the leading coupled axle, nevertheless keeping the boiler centre-line at 7ft. ½in. from rails, a height considered prudent in view of the track in the particular design under notice the main driving wheels are flangeless. The stepped pieces halfway along the "V" of the crank are for use when pressing the wheels and outside cranks on to the axle, and although shown dotted are left for future use when needed.

The leading bogie is of the Colombian standard swing-link (three-point hanger) pattern with a total swing each side of 5½in., the hangers being designed to produce sufficient lateral resistance to "curve" the locomotive entirely by the bogie. Two different trailing trucks are fitted, that on the German-built engine being a "Delta" cradle type truck, whilst on the Belgian-built engine a modified "Hodges" type truck has been used; it being the intention to use the latter pattern truck for future locomotives.

The springs of the German-built engine are compensated—apart from the bogie—in one group composed of the coupled wheel springs and the rear truck, whilst in the







FIGS. 1, 2 AND 3—COLOMBIAN RAILWAYS. 3-CYLINDER, NARROW GAUGE LOCOMOTIVE B.M.A.G.

of "Bar" pattern—outside the wheels, as in all Mr. Dewhurst's designs for main line narrow gauge locomotives, is especially evident in the case of the present engines, as, apart from the facilities in respect of the application of the inside cylinders and crank axle and their accessibility for inspection and repair in these particular engines, coupled with the accessibility of the axle-boxes, spring gear, &c., common to all types of locomotives having outside bar frames, there is ample room for the valve gear, &c., thus making possible the placing of the floating lever gear behind the cylinders, or alternatively the employment of the separate inside valve gear. It may also be noted that, with the outside disposition of the frames, any desirable width of fire-box may be conveniently obtained on narrow gauge locomotives without recourse to an "armchair" and curve conditions. The angle of inclination of the inside cylinder in relation to the outsides has been kept to approximately 8 deg. The outside and inside connecting rods are 7ft. and 6ft. 6in. centres respectively, an ample length for the 20in. stroke, and one which, together with the employment of three cylinders, results in a very even turning movement making quite satisfactory the factor of adhesion of 3·42 employed.

A diagram of the main driving wheels is given in Fig. 6, from which will be evident the robustness of the crank axle obtained even on the 3ft. gauge—there being ample space for two inside cranks—and its direct connection to the wheels. Its "straightforwardness" is well adapted to resist the considerable side pressure exerted at the wheel flanges by lines with frequent and severe curves; although Belgian-built engine special provision was made for interrupting the compensation system between the main and rear driving axles. Experience has not shown either to be better than the other under the conditions in which they have been working, but it is considered that the divided system is best for high speeds, although the one group system is found to ride easiest on poor track.

The valve gear is arranged for a maximum cut-off of 78-80 per cent. in order that the engines may operate passenger trains on the 1 in 33 to 1 in 23½ gradients of the hill sections when required. The reach-rod of the reversing gear is tubular, so as to provide vertical and lateral rigidity without intermediate support, the operation of the valve gear being by means of a hand-wheel and screw.

The boiler is of the straight-topped type, with round-

topped fire-box having large water spaces around it; the inside fire-box crown is curved and direct radial staying is employed, as will be seen from the sectional drawing. Three arch tubes are provided. All tubes are of steel and the inside fire-box also is of mild steel, the tubes being fixed to the fire-box tube plate, according to Colombian standard practice, by expansion combined with the formation of a shoulder on the water side and a bead on the fire side, thus obtaining a "locked" seating; the beads are afterwards electrically welded to the tube plate. It is of interest to know that no cases of leaking tubes have been experienced in service with tubes so applied to boilers.

The superheaters in the German-built engine has a ratio of superheating surface to evaporative surface of 1 to 3·70, and in the Belgian-built engines 1 to 4·27, and resulting from the service experience the proportion of 1 to 4·0 has been standardised for future engines, this being in accord with the later ratios adopted for Colombian standard locomotives in which the ratio has been progressively raised from 1 to 4·4 to 1 to 4·1 in the most recent engines. The superheating surface is measured on the inside of the units. It may be noted that the ratios recently adopted are considerably higher than those

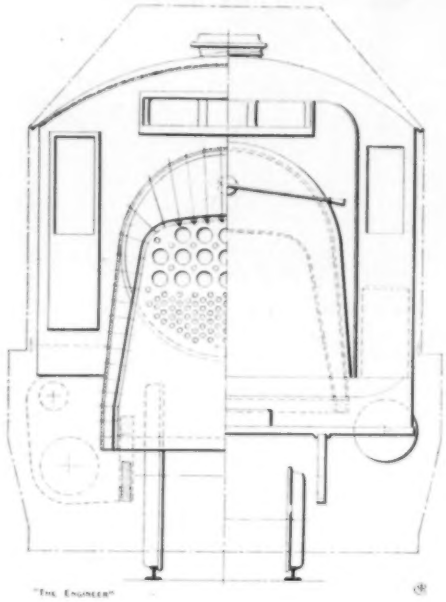


FIG. 5 FIRE-BOX AND REAR VIEW OF CAB

generally used in Great Britain, where most recent locomotives have a ratio between 1 to 4·3 and 1 to 5·0.

The engines run the fast passenger trains on the Cauca Valley section of the Pacific Railway between the cities of Cali and Cartago, a distance of 107½ miles in each direction, with trains averaging twelve vehicles equal to 190–205 tons at speeds up to 35 miles per hour. Although the section of line worked over does not include severe curves, yet it is not by any means straight, and the absence of rolling at even the highest speeds is remarkable for such a narrow gauge. The fuel consumption for the round trip, including lighting up, shunting and other incidental duties, over a considerable period has been 66 lb. per train mile—*i.e.*, open mileage only credited—using a very inferior and dusty almost lignite coal of the following analysis:—

Fixed carbon	40·52
Volatile material	46·18
Sulphur	1·34
Ash	10·70
Moisture	1·26
	100·00

Physical Characteristics.

	Per cent.
Lump	10
Pebble	42
Dust	37
Dirt	11
B.Th.U. per pound	12,717

The fuel consumption, which at first sight appears high, is in reality very low when the class of fuel—practically dirty lignite—is taken into account, being actually a reduction of 28 per cent. on that of previous smaller locomotives on the same service. The gradients worked over include 1 in 100, these generally having a down run compensated by a similar rise, but there is also a short piece of 1 in 60.

Although designed for fast trains on comparatively easy sections, the engines are adapted for curves as sharp as 3 chains radius and have handled passenger trains over the mountain section of the line on which gradients of 1 in 23½ and 3-chain curves are found.

Amongst the details of design of interest are the following:—The main driving wheel tires are flangeless, being 7in. wide on the tread. The balancing of the forces about the coupled wheels is effected in the counterbalances of the cranks, and as far as possible in the case of the main driving wheels also.

Piston valves of 8in. diameter arranged for inside admission are employed,

The injectors are of the lifting type, delivering to a top-feed valve provided with a spraying device inside the boiler; the overflows are arranged to flush the ashpan

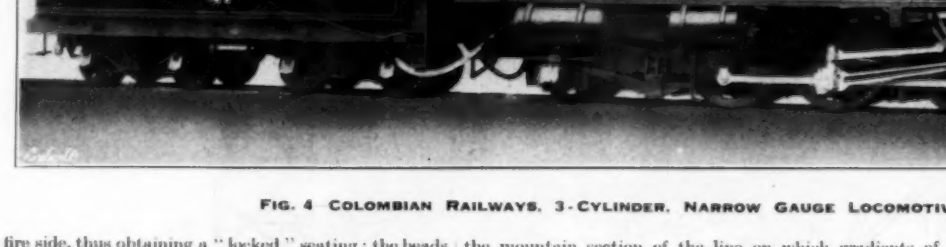


FIG. 4 COLOMBIAN RAILWAYS. 3-CYLINDER, NARROW GAUGE LOCOMOTIVE HAINE-ST.-PIERRE

Government Railways of Colombia.—4–6–2 Type Three-cylinder Locomotives, Pacific Railway.
Conditions.

Gauge	3ft.
Curves (minimum radius)	264ft.
Gradient (maximum)	1 in 60
Bridges (Cooper's E)	"E–30"
Rails (per yard)	55 lb.

Principal Dimensions (additional to diagram).

Engine:			
Cylinders (three)	16in. by 20in.		
Piston valves, diameter	8in.		
Wheels, diameter of leading bogie	2ft. 2in.		
Wheels, diameter of driving and coupled	4ft. 2in.		
Wheels, diameter of trailing truck	2ft. 4in.		
Wheel base, adhesion (rigid)	9ft. 6in.		
Driving and coupled journals	8in. diam. by 7in. long		
Fire-box shell, width	5ft. 8½in.		
Grate, length	6ft. 0⅛in.		
Grate, width	5ft.		
	B.M.A.G.		H.S.P.
Flues, number (outside diameter, 5½in.)	19	21	18
Tubes, number (outside diameter, 2in.)	106	103	110
Superheater tubes, number (outside diameter, 1½in.)	76	84	72
Heating surface—			
Flues and tubes, sq. ft.	1203·5	1222·6	1214·4
Fire-box, sq. ft.	106·0	97·6	105·5
Arch tubes (three 3in. diameter), sq. ft.	14·5	14·3	14·6
Total evaporative, sq. ft.	1323·0	1334·5	1334·5
Superheater surface (measured on inside), sq. ft.	330·0	360·5	312·5
Equiv. H.S. total evap. H.S. + 1·33 superheater surface	1763·0	1815·0	1751·0
Grate area	30·25 sq. ft.		
Boiler pressure	180 lb. per sq. in.		
Maximum width (over cylinders)	9ft.		
Tender:			
Wheels, diameter	2ft. 4in.		
Water capacity	2750 gallons (Br.)		
Fuel capacity, coal	5½ tons (Br.)		
Tractive force:			
Rated tractive force (at 85 per cent. boiler pressure)	23,500 lb.		
Rated tractive force (at 75 per cent. boiler pressure)	20,736 lb.		
Tractive force (at 85 per cent.) per ton of weight (engine only)	416 lb.		
Ratios:	B.M.A.G.		H.S.P.
Adhesion weight / Tractive force (at 85 per cent. B.P.)	3·42	3·27	3·37
Ditto (at 75 per cent. B.P.)	3·87	3·72	3·83
Rated tractive force (at 85 per cent.) / Equivalent heating surface	13·3	13·2	13·4
Total evaporative surface / Grate area	43·7	44·4	44·1
Total evaporative surface / Superheating surface	4·01	3·70	4·27
Grate area / Area of gas passage	8·57	—	—

sides and a coal watering pipe is led from the delivery pipe on the fireman's side, providing water under pressure. All the subsidiary fittings, except the steam and water gauges, take steam from a turret placed on the fire-box top in the cab, fitted with a shut-off valve, to which a large pipe leads from the dome, thus avoiding many attachments on the boiler backhead.

The grates are of the rocking "finger" type with drop-plates at the front end operated from the footplate; the air spaces are specially narrow to suit the small and dusty coal used.

An ample number of washout holes are provided for cleaning the boiler; in addition to the usual holes there are washout and inspection holes at points slightly forward of the fire-box tube plate and to the rear of the smoke-box tube plate; a mud door is also provided under the barrel a short distance from the throat plate.

A 9½in. Westinghouse air compressor is fitted to the side of the smoke-box, the exhaust being piped to the exhaust passages of the cylinder casting to minimise draught on the fire and annoyance when the engines are standing.

The cab is of steel, lined with wood, and in addition to the ample ventilator is constructed with an air current insulation in the roof, as will be seen in the drawing Fig. 5.

Apart from the foregoing, the usual Colombian standards have been incorporated in the design of these engines, including bogie frames of bar pattern placed inside the wheels with inverted plate springs working in equalising cradles on each side; fire-box crown stays with button heads inside the fire-box and having the three front rows composed of independent expansion stays; "Webb" pattern fire hole with double sliding doors; superheater unit joints of spherical type and no jointing; regulator of the double-beat poppet pattern with pull-out regulator handle having a fine adjustment; safety valve of "pop"

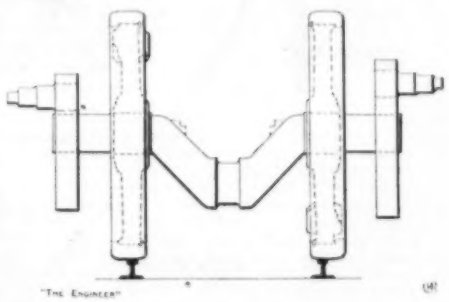


FIG. 6 MAIN DRIVING WHEELS

type mounted 6in. above the boiler barrel; removable smoke-box front with small door fastened by dogs and with a steam-operated ash ejector under the smoke-box; valve and cylinder lubrication by a hydrostatic lubricator provided with a master cut-out cock and placed in the cab; compressed air sanding apparatus with four deliveries for forward running and two for rearward; electric headlights and train lighting equipment with lights over the motion; tender bogies of arch bar type, with self-trimming coal space and having the side sheets swept downwards towards the rear where not forming part of the coal space.

Dam-Building Machines.

Two remarkable machines, or structures, are now in course of erection in the Bath works of Stothert and Pitt, Ltd. They are illustrated in the engravings herewith and on page 688, and are to be used in the construction of the Cauvery Metur Dam in the Madras Presidency of India. The general principle of mixing and placing concrete by machinery is not, of course, new, but these machines are really noteworthy on account of their magnitude. Each is 286ft. high, weighs some 2000 tons, and contains about 500 horse-power of electric machinery. They have been ordered solely for the one job, and it is expected that they will save about two years in the construction of the dam. Hence their capital cost will be justified. The Metur Dam, it should be mentioned, has been under consideration for many years, but it was only recently that any agreement could be arrived at for proceeding with the project. It will impound 90,000 million cubic feet of water, which will be utilised for regulating the flow of the river to extend local irrigation.

The Cauvery Metur Dam is to be of concrete throughout and it will contain about 3,200,000 tons of that material. The top of the dam will be 239ft. above the foundations and it will be 5300ft. long. The whole of this great building is to be commanded by the two machines under review, and it will be readily understood that they must be large structures. In fact, the first one, as it stood when we inspected it, at less than half its total height, dominated the landscape round Bath. When completed they will be 286ft. 6in. high.

The object of these machines is to minimise hand labour

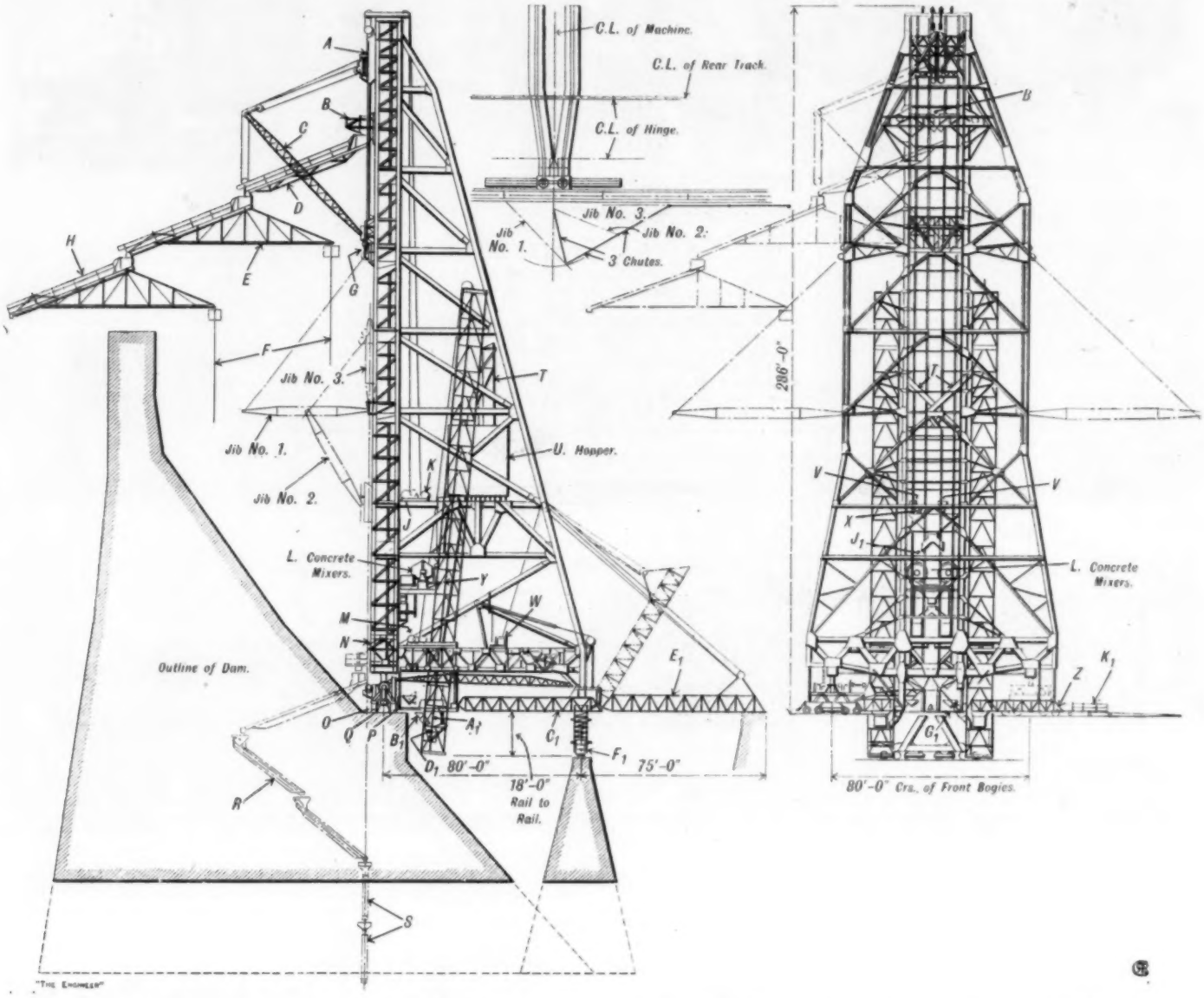
and to expedite the building of the dam by mixing the various ingredients of the concrete on the spot and elevating the mix to such a height that it will gravitate down chutes to the place where it is required. The machine consequently involves the provision of an adequate supply of materials, which will be used at the rate of 166 tons an hour, an elevator for raising these materials to an overhead hopper, two concrete mixers, two hoists for raising the mixed concrete to the appropriate height, and a system of chutes for delivering the concrete over a wide area. All this plant is embodied in one structure—for each machine—which is capable of travelling along rails laid on the downstream side of the dam. One set of metals is to be laid on a bench near the toe of the dam, as will be seen from the drawing, while another will run along the top of a specially built wall slightly further downstream. The two lines of rails will have a difference of 18ft. in level. Towards the two ends of the dam the rails will have to rise up out of the valley to accommodate the natural contours, with a gradient which is estimated at about 1 in 30, but the mum load will be no more than about 45 tons per wheel in ordinary working conditions, with a fair breeze blowing.

Each of the bogies is provided with a separate travelling motor of the alternating-current type, and it is considered that by these means the synchronous movement of the three will be attained; but as an added precaution against their displacement, relatively to one another, a light horizontal triangular framework has been introduced to tie the bogies together.

The tower is carried on the three bogies in the following manner. At the bottom of the tower there is a deep girder framework capable of transmitting the whole vertical load to three points, one above each bogie. At the back there is a hinge on the top of an A frame built on that bogie, which carries the back leg of the tower and allows it to rock when necessary. In the front the load is transmitted to the bogies through two vertical pintles of solid steel on which there is cut a buttress-form thread. A spherical seating is provided to accommodate any rocking of the bogie. The screws, which each support a load of some and sand. The materials are run out of the hopper as required into batch-measuring hoppers and thence down to either of the two concrete mixers. The cement is also added from bags brought up by one of the lifts.

The two concrete mixers are arranged towards the front of the machine some 40ft. above rail level, and each of them is capable of turning out 2 cubic yards, or 3¼ tons, of concrete per batch, which, at the rate of twenty-four batches per hour, gives a total output of 168 tons per hour.

The mixed concrete from either or both of the mixers is tipped into a hopper, which bifurcates at the bottom and is fitted with a valve for sending the material down either of the shoots into the skips of two hoists running up the front of the tower. It will be noticed that the whole of the arrangements for handling the dry and the mixed concrete are in duplicate and are interconnected, so that either side can be used to supply the other. The skips of the two hoists will each take a full batch of concrete and are operated by a winch at the main hopper level. They are used to raise the concrete to such a height that it will gravitate down



A. Top Portion of Sliding Frame.
B. Receiving Hoppers.
C. Jib, 68ft. Centres.
D. 50ft. Trussed Chute.
E. 50ft. Heavy Counterbalanced Chute.
F. Chute Anchor Ropes.
G. Footstep of Chute Crane on Sliding Frame.
H. 50ft. Light Counterbalanced Chute.
J. Winch for Sliding Frame.
K. Winches for Mixed Concrete.
L. Concrete Mixers.
M. Winches for Aggregates.
N. Hoist Bucket for Mixed Concrete.
O. Front Bogies.
P. Frame for Turntables.
Q. Two 2ft. Gauge Tracks.
R. Three 50ft. Trussed Chutes.
S. Two 50ft. Counterbalanced Chutes.
T. Distributing Chutes.
U. 500-Ton Storage Hopper.
V. Measuring Hoppers.
W. Hand Winch for Approach Bridge.
X. Sand Hopper.
Y. Mixer Operating Platform.
Z. Ramp Girder.
A_1. Side Chute for Aggregate.
B_1. Front Chute for Aggregate.
C_1. Skew Bridge (on one machine only).
D_1. Aggregate Hoist Bucket.
E_1. Approach Bridge (on one machine only).
F_1. Rear Bogie.
G_1. 7ft. Turntable.
J_1. Batch Hoppers.
K_1. Traverser.

GENERAL ARRANGEMENT OF TOWER FOR MIXING AND PLACING CONCRETE FOR DAM CONSTRUCTION.

machine will, naturally, have to be kept "plumb" in all conditions, and one of the interesting details is the arrangement used for levelling the superstructure while working on these slopes. In this connection it should be pointed out that the half-tone engravings show the machine erected on a false work representing the bench of the dam, but with a gradient of 1 in 20, which, it was considered, would provide an ample margin for contingencies.

As will be seen from the drawing, the machine comprises a tapering tripod tower with a vertical front face, within which all the working machinery is housed. To the rear there extends a hinged gangway across which the trucks of material are to be brought. This gangway will be served by a traverser, working in conjunction with two lines of light railway, so that full and empty trucks can be handled without interfering with one another. An electric capstan is provided for manœuvring the trucks.

The tower is carried on three bogies, two in front and one behind, with two pairs of rails in front and one pair behind. Each of the bogies has sixteen wheels, or it might be better to say that each half of the twin bogies at the front has eight wheels, while the back bogie has sixteen wheels on two rails. A complete system of levers is provided for equalising the load on the wheels, and the maxi-700 tons, work in conjunction with nuts operated by separate electric motors with sufficient power to raise either corner of the tower at the rate of one foot in three minutes.

The general construction of the superstructure needs little comment, as it is of orthodox arrangement and is well illustrated in the drawing and engravings; but it should be pointed out that in the case of the latter pictures there may be some confusion between the new structure itself and the cranes which are being employed in its erection. The framework of the latter can, however, be traced by following it up from the ground level.

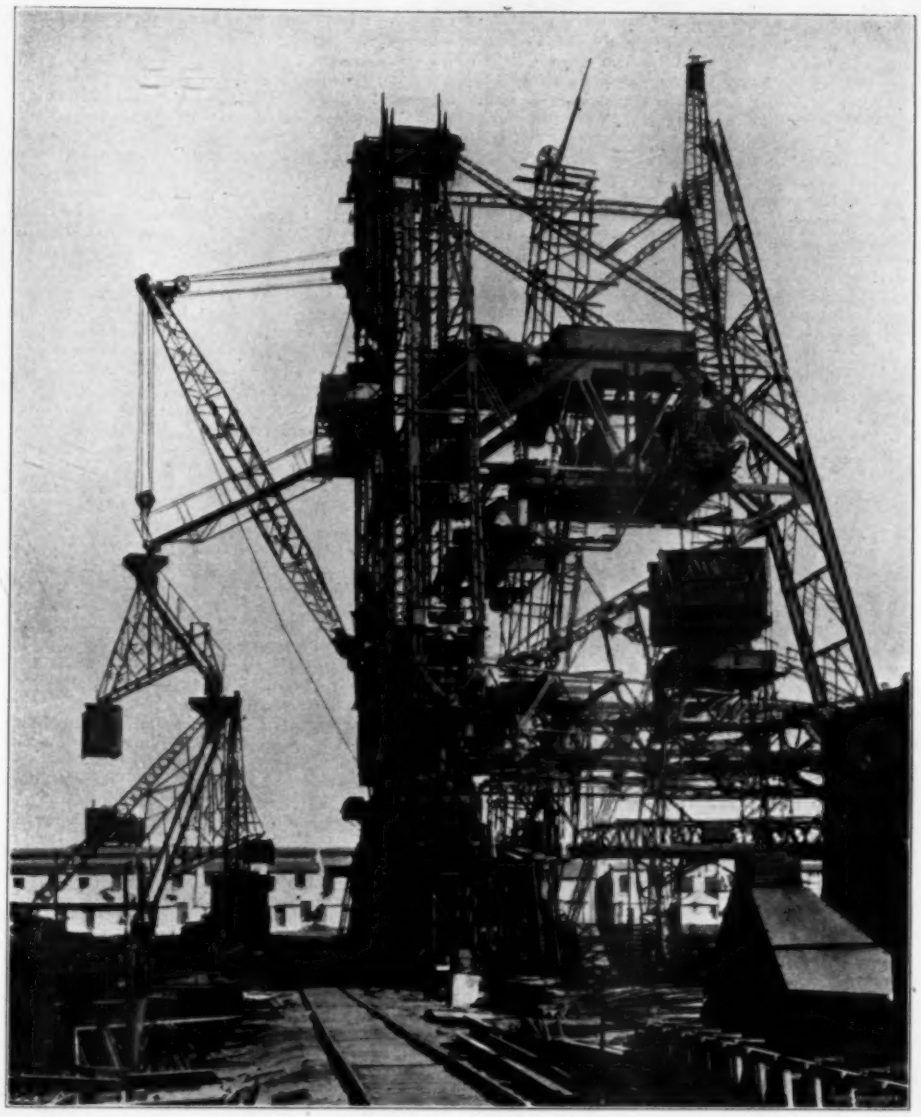
It may now be best to continue by tracing the route of the materials as they are handled by the machine. The aggregate, sand and cement, are brought in to the bottom of the machine by the light railway already described, and the two former are tipped into the boot of one of two elevators or lifts reaching about halfway up the tower. These elevators rake backward slightly and are plainly indicated in the drawing. At the bottom they are so arranged that they can be fed from either track of the rails, in front or at the sides. At the top they command shoots leading to a storage hopper with a capacity of 500 tons. This hopper is divided into three compartments for accommodating large stones or "plums," broken stone, chutes to the site of operations. At the beginning of the work, when the dam foundations are being put in, the hoists will, of course, not be necessary and the concrete will be shot down from the concrete mixers, as indicated by the broken lines of the drawing. During this part of the work the chutes, a series of which is plainly shown in one of the engravings, will be slung from two jib cranes mounted on the corners at the front of the crane.

For the higher stages of the work a different arrangement for supporting the chutes is provided. Running up the whole height of the tower there are two sets of guides on which tall sliding frames move. These frames are about 90ft. tall and at the bottom support the jibs of the cranes for carrying the chutes—see the drawing. About halfway up the height of the frame there is a small hopper for guiding the concrete into the first length of the chutes, and just behind this hopper there are guide rails which automatically tip the skip of the hoist. The whole arrangement can, of course, be raised or lowered on the face of the tower, to suit the height of the work, by a winch at the hopper level. The chutes themselves need no description, as they are of the type commonly used for this class of work.

Although we have not enumerated all the motors

MACHINE FOR BUILDING THE CAUVERY DAM

STOTHERT AND PITT, LTD., BATH, ENGINEERS



installed on the machine, it will have been gathered that to perform all the operations mentioned a considerable number is required and their aggregate output is some 500 horse-power. They are of the direct-current type and are supplied with energy by a pair of rotary converters placed on the lower decks near the rear bogie. None of the illustrations show these converters in place, as on the occasion of our visit the supply was being taken from the works mains.

In view of the weather conditions which are experienced in the valley of the Cauvery, which include storms of wind that develop very suddenly, most careful calculations have been made as to the stability of these machines under various conditions, and it has been assumed that they may be subjected to a maximum wind pressure of 50 lb. per square foot of exposed surface, while the pressure during normal working may be as much as 10 lb. per square foot. Naturally, they have been so designed that, in the worst conceivable conditions, they are stable. That is to say, with the wind blowing upstream and producing a pressure of 50 lb. per square inch on the back of the tower and the chutes hanging out at the maximum radius there is still a downward load on the rear bogie of over 100 tons. On the other hand, if a wind of the same strength is blowing downstream and the chutes are snugged in against the tower the total load is very nearly equally distributed between the three bogies.

Although the broad principle of mixing concrete at a central station and placing it mechanically has been, as we have already suggested, developed on a large scale by engineers of other countries, we believe that this is the first occasion on which the idea has been extended to such a magnitude, when it is borne in mind that the whole of the apparatus is movable. It will be most interesting to follow the career of these machines, both during their active life and after they have served their immediate purpose.

American Engineering News.

Classification of Coal.

WITH an annual output of about 600,000,000 tons of coal annually in the United States, the magnitude and value of this commodity make it highly desirable to have some system of classification for the several grades or varieties. Such a classification has been proposed by Professor Samuel W. Parr, of the University of Illinois, basing it on the fuel ratio which in a general way serves as an index of coal values. In this classification the coals are arranged in the order of ratio of fixed carbon to volatile matter, which ratio has a constant relation to the evaporative power of the fuel tested, as shown by Professor Walter R. Johnson in a report to the United States Navy in 1844, and elaborated by Professor P. Frazer before the American Institute of Mining Engineers in 1877. In the Parr system of coal classification the values are as follows :—

	Unit volatile, per cent.	Unit B.Th.U.
Anthracite	0– 8	15,000–16,500
Semianthracite	8–12	15,000–16,500
Bituminous A	12–24	15,000–16,500
Bituminous B	24–50	15,000–16,500
Bituminous C	30–55	14,000–15,000
Bituminous D	35–60	12,500–14,000
Lignite	35–60	11,000–12,500
Peat	55–80	9,000–11,000
Cannel	50–80	15,000–16,500
Sub-cannel	55–80	14,000–15,000

Sintering Clay for Concrete.

Several special kinds of aggregate for making light weight concrete, including burned clay products, have been developed, but a new process has been tried experimentally in the production of burned clay of a honeycomb or spong-like texture. This process is a modification of the sintering process used in the metallurgical industry for fusing light ores, ore dust and concentrates into lumps suitable for charging into smelting furnaces. But, as adapted to clay for concrete aggregate, the process produces a hard material of open or honeycomb structure, while in metallurgical work this form of structure is not important. In the sintering process, which is said to require much less coal than kiln burning, a moist mixture of coal and crushed clay is fed upon a slowly moving conveyor or endless travelling grate, and its upper surface is ingited by a downward flame blown upon it from a furnace beneath which the grate travels. Combustion then progresses downward through the layer of material. When this sheet of fused material or sinter leaves the furnace, it is at once chilled by a blast of coal air blown upward through the grate. This hardens the material and causes it to break up into lumps, which are discharged as the grate passes over a pulley at the end of its travel. The product has a specific gravity of about 1·3. It is only in the experimental stage, and is not yet a market material.

High Head Hydro-electric Plant.

The new Bucks Creek hydro-electric plant of the Feather River Power Company, in California, with a static head of 2561ft., has the highest working head of any such plant in the United States. From the forebay extend two penstocks of triple-riveted, double butt-strap, steel pipe beginning at 4½ft. diameter with ⅜in. plates, and ending at 3½ft. in diameter, with 1¼in. plates. This construction extends only to vertical depth of 1250ft. Beyond that is 36in. steel pipe, ⅜in. to 1in. thick, but reinforced by steel bands. These banded pipes extend to the power station, where each one branches into two 26in. pipes terminating in the jet nozzles. The station equipment consists of two impulse wheels on horizontal shafts, each rated at 35,000 H.P. at a speed of 450 revolutions and under a head of 2561ft. The jets, two for each wheel, are 8in. in diameter. For each power unit there is an exciter driven by an impulse wheel developing 450 H.P. at 900 revolutions. By means of a cross connection between the 36in. pipes, both penstocks can be made to serve either one of the water wheels. A speed governor is actuated by a central oil pressure system serving both units. Each wheel drives a generator of the revolving field type, rated at 20,000 kilowatts, with 80 per cent. power factor and generating 60-cycle current at 11,000 volts. By means of a remote control system, the valves at the reservoirs and tunnel intakes above the forebay are operated from the power station.

Steamers for Automobile Cargoes.

Transporting automobiles in bulk from the great manufacturing plants in and around Detroit by means of the large cargo steamers on the Great Lakes has developed into an important business. The ordinary steamers may carry thirty to seventy cars in addition to other freight, but steamers utilised for this service exclusively will carry 500 to 650 cars. In some cases the cars are run by gangways on to the upper deck and into side hatches of the lower decks. But many of these boats are equipped with lifts for handling the cars between decks. The cars are driven on board, lowered or raised to the proper deck on the lift and then run into position, being close-packed to get every possible car on to the vessel. The wharf or transit shed may have capacity for 1000 or 1500 cars. When the car is in position it is put in gear and the brakes are set. Those on the upper or open deck may be covered with tarpaulins, but in good summer weather that is not done. Trucking companies have developed special motor trailers which will carry three or five automobiles each from the landing port to destination. The larger steamers average about 12 miles an hour. From Detroit the distances to large ports are 634 miles to Chicago, forty-eight hours; to Buffalo, 261 miles; while the run to Duluth is about sixty-six hours. From Detroit to Cleveland, an overnight run of 108 miles, from 350 to 400 cars a day are shipped by water.

Odour and Aeration of Drinking Water.

The water supply of St. Paul, U.S.A., has for several years been the subject of complaint as to a musty or earthy odour, although the quality was good. This odour was always present, though its intensity varied with the season and the weather. A study of the free oxygen content indicated that the odour increased when the dissolved oxygen content was low. After extended experiments an air compressor was installed for aerating the entire water supply, and this treatment has practically eliminated the complaints, at a cost of about 2s. 6d. per million gallons of water. The rate is about 6000 cubic feet of air per million gallons, distributed at a pressure of 5 lb. to 6 lb. per square inch. On the basis of 20 per cent. of oxygen in the air, about 10 parts per million of oxygen is added to the water. The air is forced through the water at such a rate as to act in the same way as ventilating a room, the odour of the gases carried out of the water by the escaping air being noticeable when the odour is high. The trouble is considered due to gases formed by the decomposition of organic matter in the absence of free oxygen. For the treatment of algal growths in the reservoir, which cause odours, copper sulphate is used, but only in small doses, as the fish are very susceptible to poisoning by this sulphate. However, the copper sulphate soon becomes inactive by entering into chemical combination with the carbonates in the water. Twice in 1927 the water was dosed with a little less than 2 lb. of sulphate per million gallons of water.

Large Bascule Bridge.

In consequence of the straightening of a bend in the Chicago River, the city has built a double-leaf bascule bridge, 204ft. between centres of trunnions, to carry Twelfth-street over the new channel. It is situated just west of the present 220ft. swing bridge, and will give a clear channel without the obstruction of a pivot pier. Each leaf consists of two deck trusses with curved bottom booms, giving a headway of 20ft. to 45ft. for navigation. These trusses are 60ft. apart, and have cantilever floor beams for the 17ft. footways. The tail pits are massive concrete boxes supported on cylindrical piers sunk to rock at a depth of 50ft. to 60ft. Across each pit is a steel box girder supported on columns, and upon this girder are mounted the trunnion bearings. Each trunnion is a 24in. steel shaft, 8½ft. long. In the heel of each truss is a rack of 13ft. pitch radius, engaging an operating pinion which is driven through a train of gears by a 75 H.P. electric motor. For the roadway floor beams between the trusses carry twenty-six lines of longitudinal girders, upon which is 6in. by 12in. creosoted planking laid transversely and covered with 2in. by 8in. asphalt planks, laid diagonally. The tramway lines have 9in. grooved rails supported on cast steel chairs riveted between pairs of longitudinal floor girders. Each leaf weighs about 2000 tons. Construction work was difficult, since the bridge was built across a maze of railway tracks on the site of the future channel Both leaves were erected in the open position, with street traffic passing through them.

THERE is every indication that 4,000,000 dollars will be available within a short time for original industrial research work in Ontario, which is twice the amount originally expected.

An Exposition of Cable Charge and Discharge.

By FRANCIS G. W. TREE.

TRUE it is that a phenomenon which can be visualised is the one most likely to be understood. This possibly accounts for the failure of many to understand fully those phenomena pertaining to the charging and discharging of cables. An explanation given in a manner which should make many points quite clear may therefore be useful. As a fundamental basis, we will consider a cable as being representative of a condenser possessing constant capacity and no losses, connected to a circuit of constant resistance and inductance. If supplied by an alternating voltage, it will receive a charging current which will lead the applied voltage by 90 deg. For reasons which will be explained later, this charging current is limited to the metallic conductive circuit, and does not pass into or through the dielectrics. The charging transient which follows the closing of the circuit will be oscillatory if the circuit resistance is below a certain critical value, and impulsive if the resistance is above that value. This transient is usually of higher value than the permanent charging current, but disappears very quickly. If, instead of an alternating voltage, a continuous voltage be applied, the same transient occurs. Therefore we can proceed to examine the formation of the internal charges.

Formation.—Following the application of the initial voltage, an electro-static field appears, and provides an electro-static flux density. However, no internal charge can exist, as such would necessitate a passage through the dielectrics. Owing to the high resistance of the dielectrics, the time required for the charge to penetrate would be much longer than the duration of the external transient. Hence, since at the moment of applying the voltage there can be no charge on the dielectrics, no electro-static flux can terminate in them. All the lines of flux must, therefore, pass from end to end of the cable, and finish at the terminals. The initial voltage distribution between the dielectrics will be such as will provide a uniform flux density throughout the entire length of cable. This means that the voltage distributed between the dielectrics will be inversely proportional to their specific capacities. Now, if the resistance of the dielectrics was so extremely high so as to render conductivity impossible, no further charge could take place. This follows from the fact that, being supplied by a continuous voltage, the current ends after the initial transient ceases.

In actual practice, of course, dielectrics are very much unlike those assumed in the foregoing and possess quite definite conductivity. Likewise, the specific capacities and resistances of cable dielectrics are by no means all of the same value. Therefrom, being proportional to the conductivities and potential gradients of the dielectrics, the current densities cannot be the same. These points indicate that there will be a current flow and also a difference of current density between the dielectrics. Consequently, owing to the difference in current density, an electro-static charge builds up between the dielectrics. This charge lowers the voltage gradient, incidentally lowering the current density on the dielectrics of high current density and raising the density of those of lower current density. The difference in current density is thereby reduced and likewise the rate of formation of the internal charges. Continuing, as it does, until the current densities are all of the same value, no further charge takes place after that point has been reached. It is here worthy of note that, with an alternating voltage impressed on dielectrics of finite conductivity, the charging current does not lead the applied voltage by exactly 90 deg. On the contrary, there is a definite current component which, though minute compared with the charging current, is invariably larger than the current which passes through the dielectrics. It is representative of the current passing through the dielectrics, and also the dielectric losses due to the alternating field. There is some difficulty in obtaining accurate measurement of the proportions of this factor, but tests seem to indicate that the dielectric losses are much larger at high temperatures if resinous impregnated dielectrics are used.

"Soaking-in" Process.—The current remaining after the initial transient has ceased gradually decreases to a final minimum value. There is, therefore, a current passing into and through the dielectrics for a definite period of time afterwards, and this current is commonly known as the "soaking-in" current. It consists of current sent by the applied voltage through the dielectrical resistances, and also a transient current which supplies the internal charges over them. The first mentioned component is, so to speak, permanent and is dissipated as heat. Further to this, and resultant from the slow transient referred to, there is a change from the initial voltage distribution due to capacity, to the final voltage distribution due to the resistances of the dielectrics. There is also a change from uniform flux density and ununiform current density to ununiform flux density and uniform current density. The energy which is electro-statically stored in the cable increases during the slow transient of the internal charge, to the extent of half of the transient component. This means that the energy stored in the cable will reach a maximum at the end of the slow transient, when the current due to the applied initial voltage will be at a minimum.

The stored energy and likewise the capacity are at a minimum at the commencement of the initial charge. Therefore, briefly speaking, a cable having composite dielectrics differs from one with uniform dielectrics in that in the latter the energy is stored in the metallic components. In the former, the energy is stored also in the dielectrics as an electro-static charge. This energy can be discharged from the dielectrics, but, owing to their high resistance, the process is slow. From this point we can account for that often misunderstood phenomenon which is often attributed to some form of hysteresis, but which is actually due to resistance pure and simple.

Dielectric Resistance.—The internal conditions of composite dielectrics, when alternating voltage is applied, are the same as those of continuous voltage. However, the conduction current passing into the dielectrics as the result of alternating voltage is not the same as the final value of the conduction current from continuous voltage. It is usually much larger and is the transient value of the conduction current, *i.e.*, the initial value of the slow transient. Under alternating voltage conditions, the watts loss is therefore much larger than when continuous voltage is applied. Hence, assuming that there are no other losses, the energy component would be much larger than the conduction current of continuous voltage. Resultant therefrom, the dielectric resistance from the energy current and alternating voltage will be much lower than the resistance with continuous current. It is certain, however, that the alternating energy current and the resistance calculated from it represent the results of a true ohmic effect. They are independent of frequency, and, as previously stated, are often misunderstood as being resultant from hysteresis. Briefly detailed, they represent the resistance effects of the medium between the internal charges and the external circuit. Of course, these losses must be coupled to those due to ionisation, and probably some true form of hysteresis.

Dielectric Strength.—Another factor which must be brought under consideration is that known as the dielectric strength ratio. This factor is directly linked up with all problems of cable charge and discharge, being directly connected to all matters pertaining to puncture voltages of dielectrics. As might be expected, the striking distance of direct voltage is equal to that of alternating voltage, when air forms the dielectric. However, tests have proved that cable dielectrics can withstand materially higher direct voltages than alternating voltages. It may here be an advantage to point out that the dielectric ratio is the ratio of the direct disruptive voltage to the crest value of the alternating disruptive voltage. Various tests have proved that a ratio less than unity is given by petrolatum and oil dielectrics, but the difference rarely exceeded 10 per cent. Cloth, paper, mica, and solid glass indicated a ratio higher than unity. The dielectric strength ratio of some materials, such as laminated paper, has been found to vary with the conditions and increase with decrease of temperature, decrease of thickness, and increase of rate of application of voltage.

In summarising thus briefly, however, we cannot ignore the theoretical and physical aspects. It will be observed that, with constant terminal voltage, the voltage distribution between two component dielectrics, changes between the initial and final conditions. In the one dielectric the voltage gradient is higher in the initial conditions than in the final conditions, while the reverse is the case in the other dielectric. If the first dielectric is operated closer to the limit of its dielectric strength than the second one, and the terminal voltage is applied rapidly, at a certain terminal voltage it will reach its disruption gradient and puncture of the insulation will occur.

Assume now that the voltage is applied slowly, so that the final voltage distribution exists between the two dielectrics. At this final voltage distribution, for the same terminal voltage, the voltage gradient in the first dielectric is lower. Therefrom it is obvious that the disruptive gradient in the first dielectric can only be reached by a higher terminal voltage. This phenomenon of a rapidly applied lower voltage being sufficient to cause a puncture, when a slowly applied higher voltage has failed to do so, has been repeatedly observed with composite dielectrics. In the former case the dielectric passes through the initial stage of voltage distribution, where it is overstressed. In the latter case, while still below puncture voltage, it passes this stage at a lower terminal voltage, and by the time higher voltages have been reached, relieves itself by the readjustment of voltage causing a higher gradient on the second dielectric. If the second dielectric happened to be the weaker, with a rapidly increasing terminal voltage, the dielectric may have a much higher puncture voltage than with a slowly increasing voltage. In the one case, therefore, the dielectric would indicate a time lag of disruptive strength, while in the other, *i.e.*, where slow application of voltage increases the disruptive strength, we may speak of a negative time lag. We can assume that the time lag of breakdown is not a temperature effect, but is due to a resistance phenomenon. This is under the assumption that the relationship between the breakdown and the breakdown gradient is instantaneous, and that the breakdown occurs as soon as the breakdown gradient is reached.

Discharge.—Let us go back to the original composite cable of two dielectrics, which has been charged to a constant terminal voltage, and has reached the stationary conditions of voltage distribution and internal charges. If the cable is now short-circuited, by the rapid external transient, it discharges in a short space of time. In the first moment, the internal charges at the boundaries of the two dielectrics remain the same. They now discharge their energy towards the cable terminals, through the high resistance of the dielectric. This takes place in the form of a slow transient and the current gradually and eventually falls to zero. Suppose now that the cable is not short-circuited, but left fully charged on an open circuit. The internal and terminal charges then supply the conduction current which passes through the dielectrics. Charges, terminal voltage and internal voltages will then gradually decrease until they finally die out.

There now remains one other form of discharge, and this is perhaps the most important. Assume the cable to be short-circuited for a very brief period, sufficient to pass the external discharge transient and cause the terminal voltage and charges to drop to zero. However, before there has been any appreciable discharge of the internal charges, the short circuit is cleared. By the withdrawal of the terminal charges, the internal charges at the boundaries of the dielectrics are set free and their corresponding voltages become manifest. The voltage gradients thereby cause currents to pass through the dielectrics and decreases the internal charges. Furthermore these slow transients build up external charges and these appear as a terminal voltage. Thereby, a transient voltage is built up to a maximum, gradually decreases to a minimum, and then dies down to zero. Half of the energy of the internal charges is stored as the terminal charge, while the other half is dissipated in the resistance of the dielectrics, *i.e.*, by conducting the charge through the dielectrics. By deduction, therefore, we find that if the energy stored by the internal charge is half that of the terminal charge, the residual terminal charge would contain half the voltage of the initial terminal charges. Therefrom, it becomes apparent that the magnitude of the resultant residual terminal voltage may be very considerable and very large discharges may take place. There is no doubt that the latter part of the foregoing makes clear the necessity of earthing cables before commencing any work on them, and keeping them so earthed until all work has been completed. It is obviously not sufficient merely to flash a cable to earth, on the false assumption that the cable will then be absolutely "dead."

THE SCIENCE OF THE WORKSHOP.

AN excellent lecture, on "The Science of the Workshop," was given to the Graduates of the Institution of Mechanical Engineers, North-Western Branch, at a meeting held in Manchester on December 13th, by Mr. W. Taylor, Leicester. Mr. Taylor opened his discussion by asking the question, "What was meant by the science of the workshop"? He then went on to give an answer to his question by saying that the science of the workshop consisted in the study of the materials, the forces, the phenomena of Nature, which in all successful work they must use as their servants. Engineering workshop processes were generally directed to effect the shaping of materials, sometimes also to change their physical properties or appearance.

Engineers had been neglecting the science which should interest all their artisans in the shop, and they had been giving their attention mainly to the science which concerned the people who were designing the work in the drawing-office. Having had the experience of it for forty years, and having started as one of the first students in the first technical school established in London, he had watched the thing very closely, and he had been in contact with technical schools. He had seen everywhere that what they did for the young artisans who went to the technical schools was, in the main, to teach them, not the science of their own business, but the science which found its application in the drawing-office; and they were filled with the desire to get out of the shop and to get into the drawing-office. If they took, as he thought, almost anything which happened in the workshop, they would find that when science was applied to it, it could be made full of interest.

Mr. Taylor illustrated the points of his lecture by means of a number of simple experiments to show that there are a large number of phenomena in the works of the engineer which were not explained but were taken for granted.

The lecture is one which we can commend to the attention of all who have an inquiring mind, and the hope was expressed at the meeting that the Institution of Mechanical Engineers would publish it for the benefit of the seniors as well as for the younger men.

THE imports of iron and steel into Burma during the year 1927–28 from the United Kingdom rose from Rs. 100 lakhs to Rs. 185 lakhs. Belgium's share remained practically steady at Rs. 39 lakhs, but that of the United States of America declined from Rs. 36 lakhs to Rs. 25 lakhs. The increase in rails was from 1065 tons to 17,700 tons. In hardware there was an increase, in which the United Kingdom had the lion's share. In machinery and millwork the total imports amounted to Rs. 260 lakhs, against Rs. 203 lakhs in the previous year. Imports of railway plant and stock increased from Rs. 30 to Rs. 35 lakhs.

Railway Matters.

AN interesting item related in the annual Tramway Returns, recently issued as a Stationery Office publication, price 15s., is that at the end of the year—December 31st, 1927, for companies, and March 31st, 1928, for local authorities—twenty local authorities and one company had trackless trolley systems, of which the mileage was 111, or an increase of 24 miles over the preceding year. The number of passengers carried thereby was 80 millions, which was an increase of 59 per cent.

THE sudden death of Mr. David Gibson, the superintendent marine engineer, London, Midland and Scottish Railway, announced in the Seven-Day Journal of our issue of December 11th, was, unfortunately, not the only such tragic circumstance in the railway world during that week. We regret to have to record that on Tuesday, the 11th, Mr. J. H. B. Jenkins, chief chemist, Stratford, London and North-Eastern, collapsed at a meeting at the Railway Clearing House and died shortly afterwards.

AN appeal in *The Times* of December 8th from the Astronomer Royal and the President and Foreign Secretary of the Royal Astronomical Society for the adoption by the railway companies of the twenty-four hour notation in their time-tables prompts us to say that the companies would welcome such a change. They would find it a relief to be able to dispense with the suffix a.m. or p.m., and the need to use different type for the times between noon and midnight. It is, however, a matter for which they look for an expression of public opinion.

THE announcement in the daily newspapers on December 1st that the Southern Railway Company was laying 70,000 steel sleepers in the road—those illustrated and described on page 666 of THE ENGINEER of December 14th—has led to several letters of reminiscences in the Press as to the use of steel sleepers many years ago. One writer spoke of his experiences on the Sierra Leone Government Railways, and said that when the sleepers were withdrawn from use they were sold to African blacksmiths, who turned them into agricultural instruments, such as axe-heads, hoe-heads, and bill-hooks. The steel wedges, that kept the rail in position, were very much prized as heads for axes, and hoes, especially when they could be removed from the railway when nobody was looking!

THE port of Queenborough, which was mentioned in the Seven Days' Journal of our issue of November 30th, has had an unfortunate history. It was opened in 1876 as part of a branch off the London, Chatham and Dover Company's Sittingbourne and Sheerness line. Its success at first created the jealousy of the South-Eastern, which company extended its line from Sharnal-street to a point on the opposite side of the Medway and, emulating the patriotic example of its rival, called its terminus Port Victoria. It was opened in September, 1882. Meanwhile, in May, 1882, the pier at Queenborough was destroyed by fire and was closed for fifteen years. It was again destroyed by fire in July, 1900, and remained closed until February, 1901. The final misfortune came in May, 1911, when the Flushing steamers were centred on Folkestone instead of Queenborough.

THE much-discussed question of the provision of look-out men was before the King's Bench recently in an action by the widow of a ganger on the Metropolitan District Railway against that company. The ganger and an inspector were knocked down and killed whilst examining some points. The plaintiff claimed that a look-out man should have been provided to protect the men; the defendants replied, first, that the men were not at work but only inspecting; and, second, that the onus for providing a look-out man lay with the ganger—the man himself. It was urged that there was no case to go to the jury, and MR. Justice Avory agreed. The family of the inspector who was killed were taking compensation under the Workmen's Compensation Act, and his Lordship deferred entering judgment to give the plaintiff an opportunity of making the necessary application under that Act.

ON August 23rd the dining car attendant on a train standing in a siding at Leeds heard a cry from P. C. Stocker, a kitchen porter, who had gone into the kitchen to clean the floor. Stocker was found unconscious and died a little later. No cause could be assigned other than electric shock, and minute traces of burning were found on his chest. In his report Colonel Trench, the official Inspector to the Ministry of Transport, describes minutely the electrical cooking equipment of the train, suggests two possible causes of the accident, and makes a number of recommendations, one being that in dining car kitchens it is desirable to avoid as far as possible the use of portable apparatus. He says, in conclusion, "The use of electric cooking in trains which are in use throughout the year offers various advantages in addition to the most important one of the elimination of gas cylinders from the vehicle. It is to be hoped that this unfortunate fatality, which was evidently due to very unusual circumstances, will not retard in any way the extension of electric cooking in dining cars."

THE Board of Trade export tables show that the value of the railway material sent overseas during the first ten months of the present year was as follows; the corresponding figures for 1927 and 1926 are added in brackets:—Locomotives, £2,932,532 (£1,726,352, £2,832,817); rails, £2,905,018 (£2,767,776, £1,317,374); carriages, £2,210,887 (£2,601,242, £2,310,875); wagons, £2,704,016 (£2,408,289, £2,522,656); wheels and axles, £656,654 (£637,304, £387,001); tires and axles, £498,648 (£561,798, £243,280); chairs and metal sleepers, £767,961 (£1,178,548, £624,029); miscellaneous permanent way, £1,128,775 (£1,252,263, £926,642); total permanent way, £6,066,685 (£6,621,741, £3,651,508). The weight of the rails sent overseas was 332,231 tons (335,985 tons, 162,658 tons), and of the chairs and metal sleepers 77,966 tons (118,970 tons, 64,212 tons). In October, 1928, alone the value of the locomotives exported was £186,470, which included:—The Argentine, £48,656; India, £36,224; Ceylon, £6771. During the same month the rails sent overseas were of the following value, and included:—The Argentine, £54,596; South Africa, £42,191; India, £35,876; British West Africa, £15,647; Australia, £8824; Straits Settlement, £5481; New Zealand, £4777.

Notes and Memoranda.

ACCORDING to the official report of the American Bureau at San Juan, Porto Rico, the hurricane which crossed the island on September 13th attained a maximum velocity of 160 miles per hour before the anemometer was damaged, and probably blew harder afterwards. The rainfall amounted to 25in.

A RECENT summary of rural power extension in the Province of Ontario estimated that by October 31st of this year 955 miles of line would either have been built or would be under construction—an increase of about eighty miles over the 1927 programme. In eight years the hydro-electric power system has built more than 4000 miles of rural lines, serving 31,000 customers and costing 8,950,000 dollars. The 955 miles approved throughout the province this year represents an estimated cost of 2,265,000 dollars.

AT the Pawtucket switching and sub-station of the New England Power Company system a 10,000 kVA General Electric outdoor rotary condenser has recently been installed for power factor correction. The machine runs in nitrogen gas in order to reduce friction losses and permit a 2500 kVA increase in the rating, the total output being 12,500 kVA. It is a three-phase, eight-pole unit, designed to operate at 13,800 volts and 900 revolutions per minute. Direct-current excitation at 125 volts is provided by a 90 kW motor-driven exciter.

THE American Bureau of Mines has worked out a method whereby calcium chloride can be produced by heating salt, silica and ferric oxide to 850 deg. Cent. in the presence of steam. The hydro-chloric acid vapours evolved can be fixed as calcium chloride without taking any precautions during the condensation to diminish the amount of moisture. The success of this process depends largely on the mechanical behaviour of such a mixture of siliceous material and salt and on the concentration of the calcium chloride obtained. Special attention is now being given to these phases of the problem.

A NOTE of warning is sounded in the following extract from a recent official report concerning the explosion of a small vertical boiler used for brewing purposes in a Nottingham inn. This explosion should have been reported to the Board of Trade by the owner without delay, and the boiler should not have been disposed of until permission to do so had been given by the officer appointed to hold the preliminary inquiry. The conduct of the owner made it difficult to ascertain the facts, but it is obvious that the explosion was caused by shortage of water due to ignorance or neglect of the attendant, who apparently had little experience with boilers. The fusible plug, which should have given warning of shortage of water by melting as soon as the water level fell below the crown of the fire-box does not appear to have operated effectively.

THE usual method of drying out newly installed generators is to run them on short circuit after the prime mover is ready for operation. Often, however, the generator is ready for drying a short time in advance of the completion of the steam or hydraulic unit, and if the generator could be dried out and ready for operation at the time the prime mover was ready, a valuable saving in operating time could be effected. In the case of the two 45,000-kVA generators at the Big Creek No. 2A plant of the Southern California Edison Company, a week to ten days' time was saved by drying the generators out with warm air before the water wheels were ready for service. A wood frame was erected over the generators and a metal roof and canvas covering provided. Electrically operated hot blast dryers of 25 kW capacity then fed into the inclosure to provide the drying.

IN the course of a lecture, given before the Manchester Geological and Mining Society, concerning the manufacture of electric detonators, Mr. T. Campbell Futers said that miss-fires are a source of danger and trouple in the pit, and no manufacturer likes to hear that one of his detonators has miss-fired. Whilst every care as far as is humanly possible is taken in the factory, considering the vast numbers passing through the works, it is impossible to guarantee that everyone will fire. A little too much flux when soldering on the wires, whilst invisible to the eye or even on test, may eventually render inefficient the flashing composition, or for some reason or other a faulty fuse may show all right on test, but on putting the battery current through it, it fails to fire, because the very fact of putting the small test current through it has in some way altered the flashing composition. Or the soldering of the wire to the fuse itself may break between the time of testing and using. Rough handling of the wires may also break this connection, as it is very delicate. But by far the most miss-fires are caused by—(*a*) bad connection between the cable and battery; (*b*) faulty shot firing batteries; and (*c*) damage to insulation of the wires in the shot hole either before putting in or after.

IN discussing the progress of 220 kV development in the *Franklin Journal* of November of this year, Mr. H. A. Gould says: Since a very large amount of power can be transmitted at 220 kV over long distances, it is questionable whether higher voltages will be required for a national transmission system. The insulation, as the most vulnerable element of the high-voltage development, is a matter of the greatest importance, its deterioration being the most rapid. It may be said that the length of life of a high-voltage system is that of its insulation. Our knowledge of the behaviour of insulating materials under variation of voltage, frequency, temperature, humidity and mechanical stresses is very meagre, hence insulation in its present form is the least susceptible to exact computation and design. The present methods of control of the important properties of insulating materials, singly and in combination, are very imperfectly developed. As a consequence, when designing insulation for 220-kV equipment more than liberal provisions are made against these uncertainties, allowing large factors of safety and thus resulting in large sizes and high cost of equipment. Matter in all physical states must be considered in discussing material used for insulation—solid insulation, such as porcelain and fibrous compounds, liquid insulation, such as oil, and gaseous, such as air. The latter always appears in connection with solids, and therefore plays an important *rôle* in the problem of insulation.

Miscellanea.

SCRAP iron now being exported from Canada to Germany is priced at about 11 dollars a ton.

IT is hoped to get the new soda works of the South Manchurian Railway at work early next year.

AN automatic telephone exchange of 9000 lines is to be installed in Nanking, at a cost of some £160,000.

THE new artificial silk factory at Drummondville, near Montreal, is producing about a ton of yarn a day.

ACCORDING to the *Far Eastern Review*, it is proposed to develop 1,000,000 kilowatts of hydro-electric power from the Yalu River.

A SCHEME of hydro-electric development on the west coast of Karafuto contemplates the development of about 3000 kilowatts.

Two high-power radio transmission stations and three receiving stations are to be put up near Shanghai, at a cost of about £60,000.

THE Canadian production of pig iron, steel ingots and steel castings during October was nearly double that of the corresponding month of last year.

THE Montreal Tramways Company has placed an order for 106 tramway cars with the Canadian Car and Foundry Company, at a cost of 1,500,000 dollars.

AS a result of Australia's fiscal policy, the General Electric Company proposes to establish a factory for the manufacture of electrical goods in Australia.

ALL efforts for saving the century-old ironworks at Newburn-on-Tyne having failed, the demolition of the last part of the works, the High Yard, is now to be proceeded with.

THE flow of gas from the latest well drilled in the Turner Valley of Alberta is such that 500 barrels of naphtha a day are already being produced, and it is intended to increase the output to 1000 barrels a day.

IT has been decided to proceed with the Slave Falls power scheme of the Winnipeg municipality. The plant is to have a capacity of 100,000 horse-power, is to cost 6,500,000 dollars, and the initial machinery is to be working in 1931.

A CONTRACT has been entered into between a group of Japanese manufacturers and the Australian Iron and Steel Company for the supply to Japan of iron ore during a period of twelve years. The order amounts in all to about 10,000,000 tons.

IT is claimed that the new wireless station at Isami-mura in the Aichi Prefecture of Japan, which is to be opened in January, will be the most powerful in the Orient. It is equipped with generating plant of 860 kilowatts and has masts 820ft. high.

WORK on the port improvements at Valparaiso has progressed so rapidly that the contractors find themselves a year ahead. The mole, which was to be 700 m. long, is being extended to 1000 m., as it was considered necessary to render the bay completely safe for shipping during the worst winter storms.

THE Aluminum Company of Canada operates a 52,325 H.P. plant at Shawinigan Falls, and purchases large amounts of power from the Duke-Price Power Company for the operation of its plant at Arvida pending the development of its Chute à Caron site on the Saguenay, where it is expected that up to 700,000 H.P. will be installed.

IT is announced by the Department of Overseas Trade that Mr. G. F. Braddock, H.M. Trade Commissioner at Toronto, who is now in England on leave, will shortly revert to the Department's staff at headquarters. Mr. Braddock will be succeeded by Mr. A. M. Wiseman, M.C., the Chief Clerk-in-Charge of H.M. Trade Commissioner's Office at Winnipeg. Mr. Wiseman will shortly proceed to England for a period of leave before taking up his new duties at Toronto in February next.

MOTOR cycles to the number of over thirty-eight thousand three hundred were registered in New Zealand as at September 30th. The number of motor vehicles in use in Ceylon at September 30th was as follows:—Cars, 10,693; taxis, 1438; omnibuses, 2263; lorries and vans, 2237; tractors, 21; and trailers, 99. The British Consul-General at Rabat reports that 167 new motor cycles were registered in the French Zone of Morocco during the quarter ended September 30th.

ACCORDING to the monthly report of the National Federation of Iron and Steel Manufacturers, the number of furnaces in blast at the end of November was 135, a net decrease of one since the beginning of the month, six furnaces having been blown in and seven having ceased operations during the month. The production of pig iron in November amounted to 544,400 tons, compared with 543,600 tons in October and 575,900 tons in November, 1927; the daily rate was thus 18,147 tons in November, compared with 17,536 tons in October. The production includes 171,700 tons of hematite, 216,700 tons of basic, 112,200 tons of foundry, and 17,100 tons of forge pig iron. Production of steel ingots and castings in November amounted to 762,500 tons, compared with 756,000 tons in October and 698,700 tons in November, 1927.

THE unwatering of Wheal Vlow Mine, Cornwall, is, according to *Tin*, nearly completed. The work took longer than expected because of the difficulties met in clearing the main adit. This adit passes Hallett's Shaft at about 240ft. down, and its mouth, 2039ft. away, is on the beach at the foot of the cliffs close to Perranporth. It was found to be badly crushed almost throughout, and the work of clearing and timbering has been always difficult and frequently dangerous, but the adit is now clear and enables the mine water to be turned into it instead of being lifted to surface. Hallett's Shaft, now nearly unwatered to the bottom level, viz., 44 fathoms, was found to be in a satisfactory condition and not much timbering has been necessary. The various levels so far opened up are also in good order, and in the very near future a detailed examination will be made of all the workings in that section of the mine.

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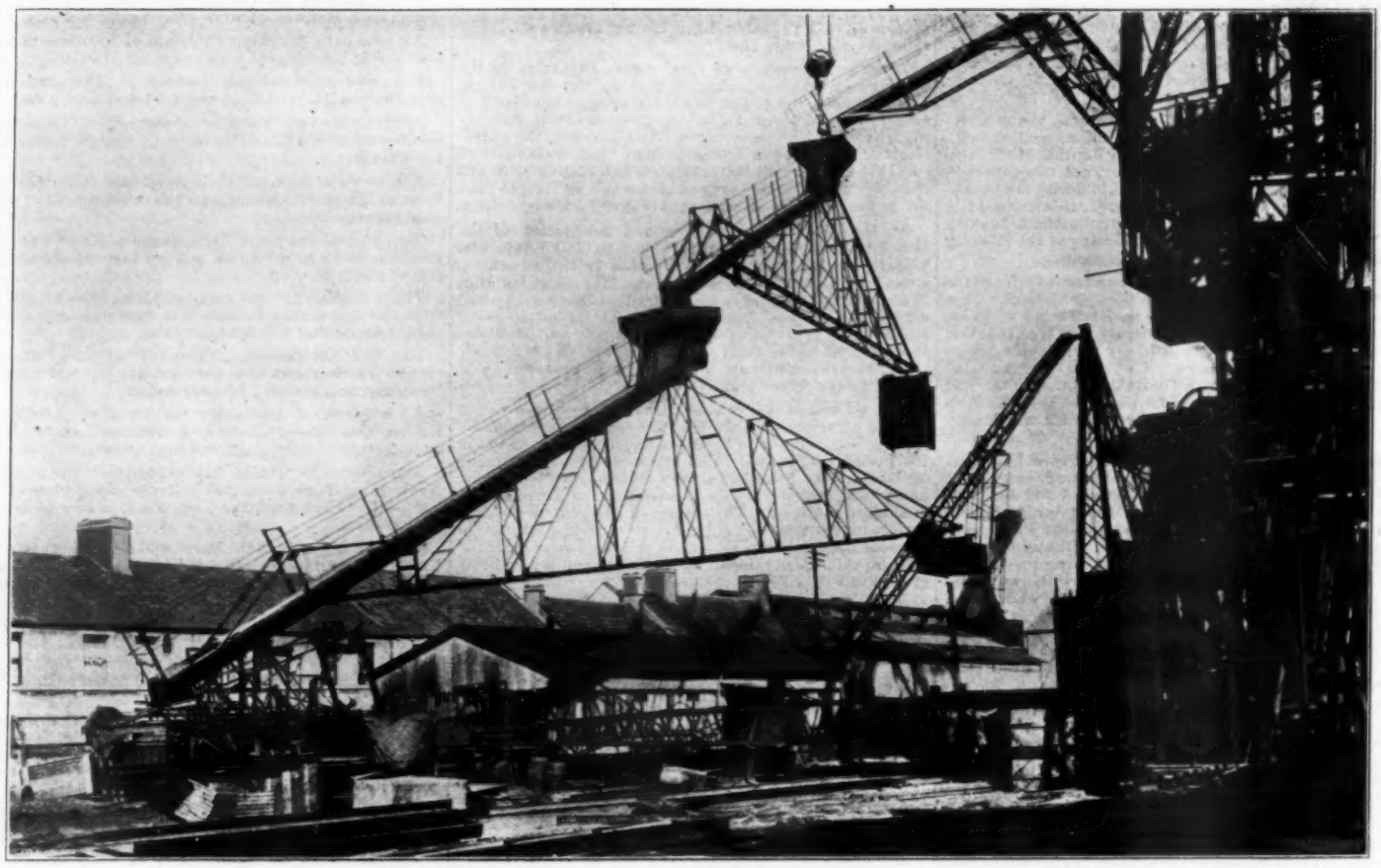
(*For description see page 683*)



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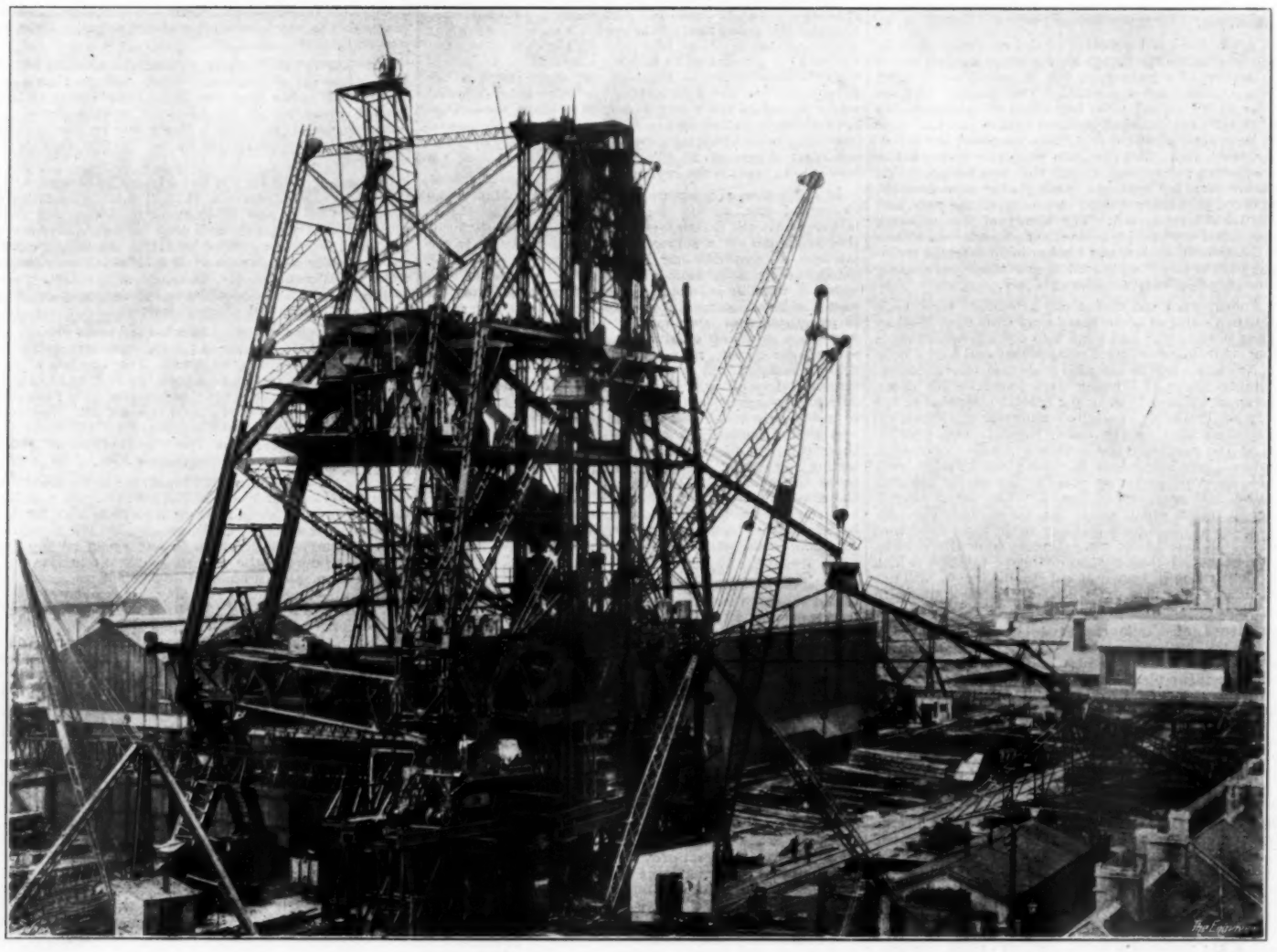

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Contents

THE ENGINEER, December 21st, 1928.	PAGE
A SEVEN-DAY JOURNAL	675
THIN CYLINDERS OF NON-CIRCULAR SECTION. (Illus.)	676
VANCOUVER HARBOUR. (Illus.)	676
INSTITUTION OF MECHANICAL ENGINEERS	679
MERCURY VAPOUR RECTIFIERS AT SHOREDITCH. (Illus.)	680
THREE-CYLINDER NARROW GAUGE LOCOMOTIVES FOR COLOMBIA. (Illus.)	681
DAM BUILDING MACHINES. (Illus.)	683
AMERICAN ENGINEERING NEWS	685
AN EXPOSITION OF CABLE CHARGE AND DISCHARGE	686
THE SCIENCE OF THE WORKSHOP	686
RAILWAY MATTERS—NOTES AND MEMORANDA—MISCELLANEA	687
LEADING ARTICLES—	
The Condenser Puzzle Again	689
Continuously Loaded Submarine Telegraph Cables	690
The Engineering Conference at Tokyo	690
LITERATURE	690
REPORT ON MACHINABILITY. (Illus.)	692
LETTERS TO THE EDITOR—	
Standardised Engine Testing Apparatus	695
Belt Drives	695
Airship R 101—Zinc-Cadmium Solders	695
SIXTY YEARS AGO	695
ALL-WELDED PETROL STORAGE TANKS. (Illus.)	696
SOUTH AFRICAN ENGINEERING NOTES	696
PROVINCIAL LETTERS—	
The Midlands and Staffordshire	697
Lancashire	697
Sheffield	698
North of England	698
Scotland	699
Wales and Adjoining Counties	699
CONTRACTS	699
CATALOGUES	699
CURRENT PRICES FOR METALS AND FUELS	700
FRENCH ENGINEERING NOTES	701
BRITISH PATENT SPECIFICATIONS. (Illus.)	701
FORTHCOMING ENGAGEMENTS	702
PERSONAL AND BUSINESS ANNOUNCEMENTS	702
CALENDARS, DIARIES, &c., FOR 1929	702

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THE ENGINEER.

DECEMBER 21, 1928.

The Condenser Puzzle Again.

IN our issue of November 2nd we drew attention to a curious phenomenon which had been recorded in connection with the tests of certain condensers, namely, that the temperature of the condensate leaving the condenser was apparently higher than that of the steam entering it. Such a result, which at first sight appears theoretically absurd, has been claimed with sufficient persistence to demand an examination of the question, especially as amongst those who have testified to the fact are engineers whose good faith and competence are above suspicion. If we leave out of account the possibility of defective instruments or inaccurate methods of measurement, the first explanation which occurs to the mind is that the condensate may be raised in temperature by the conversion of the kinetic energy of the steam into heat. We considered this possibility on the occasion referred to, and gave reasons for doubting that it could produce the effect in question. Our article has given rise to a correspondence on the subject, four contributors all accepting the phenomenon as a fact, but disagreeing widely in their explanations of it. The first, Mr. F. C. Sellens, put forward the suggestion that the rise in temperature did not take place in the working part of the condenser at all, but came about between the inlet flange and the tube surface owing to the slowing down of the steam and the consequent conversion of the kinetic energy into potential energy. Such a theory, we think, could not hold in the case of any well-designed condenser, the proportions of which would be very different from those which he assumed in order to illustrate his argument. In a modern condenser, with its low inlet velocity and very short distance from the inlet flange to the tubes, there would seem to be no room for the "Venturi" effect which he supposes. Furthermore, even if we admit a passage so perfectly proportioned as to permit of adiabatic recovery of the whole of the kinetic energy, it seems difficult to justify by calculation a temperature as high as that which he found above the tubes, having in mind the initial state of the steam.

Mr. Harold Allen goes so far as to refer to the phenomenon as being a familiar one. He attributes it, we gather, in some way to the kinetic energy of the steam, though he points out that the first effect of the recovery of the kinetic energy would be rather to increase the dryness-fraction of the steam than to superheat the condensate. The explanation suggested by Monsieur Paul Conte is of a different kind. He assumes that the steam encounters the tubes of the condenser while it is still at a temperature higher than the vacuum temperature, and becomes condensed without ever falling to the vacuum temperature. If therefore it can be taken away before it becomes further cooled, we have the phenomenon of a condensate hotter than the vacuum temperature. The question at once arises as to what is meant by the vacuum temperature, if it is not the temperature of the steam inside the condenser. The term would seem to have no other significance. There are reasons for believing that a molecule of steam is condensed, re-evaporated and re-condensed many times before it finally remains as water, and if this is so, the vapour amongst the tubes cannot possibly have a different temperature from that of the film of water with which it is continually exchanging molecules. Again, it may be pointed out, that if water and steam could be in equilibrium at different temperatures in a condenser, they could equally be so in a boiler, yet we do not hear of boiler makers claiming any difference in temperature between their water and steam. Monsieur Conte's reminder that when steam is condensed, only the latent heat is removed, really serves, it would seem, to confirm the ordinary idea that the limit of performance of a condenser would be to produce condensate as hot as, but no hotter than, the steam from which it was obtained. The letter we published from Messrs. G. and J. Weir was particularly interesting. They certify that the phenomenon has occurred in their own experience, and explain it on the theory of super-saturation. According to this theory steam may expand so rapidly in a turbine that the partial condensation which would normally take place by reason of the drop in pressure and temperature has no time to occur. Hence when the steam enters the condenser it is not in the condition which one would assume from the steam tables. It is cooler than saturated steam at the same pressure would be, because it lacks the latent heat which would have been given up had water droplets had time to form. When condensation does finally take place, it does so at a higher temperature than the steam had in its super-saturated condition, and thus produces condensate hotter than the steam was at the inlet to the condenser. That steam can exist temporarily in a supersaturated state is indubitable. The condition can be produced experimentally. We know, moreover, that steam does become super-saturated in flowing through a nozzle because the quantity which passes is considerably greater than can possibly be accounted for on any other hypothesis. But so far as we are aware there is no direct evidence that the steam is ever super-saturated at the entrance to a condenser, although such a state of affairs is certainly possible. To find out whether the steam is supersaturated or not its temperature must be compared with that which ordinary saturated steam would have at the same pressure. This involves simultaneous measurements of pressures and temp ratures at the exhaust branch. Both measurements are difficult to make. It is well known that wide variations are usually found in the pressure as determined at different points round the flange of a condenser. Hence the figure taken for the average pressure is by no means certain. The determination of temperature is beset with difficulties of another sort. If the steam is super-saturated, condensation will occur in any kind of thermometer or thermometer pocket that may be employed. The effect of this will be to make the thermometer read the temperature of saturated steam at the particular pressure, and not the real temperature of the body of the steam. Thus there is no way of finding out by temperature measurement whether the steam is super-saturated or not. Its appearance on a beam of light passing through the flow might give a fair idea of its condition, but an examination of this kind forms no part of an ordinary condenser test.

The whole question of the production of condensate hotter than the temperature of the incoming steam, seems to turn on the accurate determination of the latter temperature. It will be noticed that none of our correspondents, with the exception of Mr. Allen, makes any reference to the way in which the steam temperatures, quoted in support of their views, were measured. Mr.

Allen gives a degree of precision to the question of superheated condensate by assuming the steam temperature to be that corresponding to the pressure at the turbine exhaust. Most engineers will, we think, agree that this is the most satisfactory way of obtaining the temperature, though it involves the assumption that the steam is in the saturated condition, and thus conflicts with the theory put forward by Messrs. Weir. When the temperature is measured by a thermometer and also deduced from the pressure, it is common to find a discrepancy, the thermometer usually giving the higher figure. This fact, so far as it shows anything, tells rather against the super-saturation theory than in favour of it. The likelihood of a discrepancy is admitted by the Heat Engine Trials Committee, which suggests that the temperature deduced from the pressure is probably more accurate than that given by a thermometer. The improbability of the condensate being hotter than the steam at entrance to a condenser, is, we think, so great that the fact can only be accepted if the temperature of the inlet steam is known with all the certainty that the case demands. If there is this increase of temperature, and if the cause of it is due either to the kinetic energy of the steam or to the effect of super-saturation, it would not seem a matter to be proud of, for it could only indicate that heat, available for work, was being rejected by the turbine to the condenser. As we said in our previous article, it would be in the interests of all concerned, that the question of superheated condensate should be put at rest by a thorough investigation of the conditions obtaining in some condenser for which the effect is claimed, so that the fact, if it is one, should be placed beyond doubt and the true explanation agreed upon. The first step towards agreement would be to come to a decision as to how the steam temperature should be measured between a turbine and a condenser, for the calculated performance of both pieces of apparatus depends on the figure taken.

Continuously Loaded Submarine Telegraph Cables.

DISCOVERIES that lead to great achievements and perhaps save very large sums of money often escape the attention of many people upon whom they bestow benefit. Even engineers and research workers, engrossed in their own particular problems, may fail to perceive that important advances have been made in certain directions. In these days of specialisation and rapid scientific progress no one can hope to keep abreast with all that is going on, much less acquire a deep knowledge of a variety of subjects. While it may be fairly well known that the discovery of certain alloys that exhibit high values of permeability on the application of low magnetising forces has had the effect of considerably increasing the speed of signals transmitted over submarine telegraph cables, possibly few save those who are intimately connected with the telegraph cable industry realise the true value of the discovery. Oliver Heaviside, who incidentally died in poverty, was the first to point out that self-induction was desirable in communication cables, but it was left to others to put the idea to practical use. The principle of the inductive loading of conductors has been applied to telephony with conspicuous success, and the comparatively recent discovery of certain alloys possessing special magnetic properties has marked a great step forward in the direction of high-speed telegraph signalling. How valuable these alloys have proved for loading cables is shown in a paper on "The Continuously Loaded Submarine Telegraph Cable," read before the Institution of Electrical Engineers by Messrs. A. E. Foster, P. G. Ledger and Dr. A. Rosen, on Thursday, December 6th, a paper that aroused no small amount of enthusiasm.

For the discovery of "Permalloy," the first of these magnetic materials, two American engineers, Messrs. H. D. Arnold and G. W. Elmen, were responsible. Other alloys known as "Mumetal," "Invariant," &c., have been introduced, but the credit for having produced the first high-permeability alloy belongs to these two American investigators. As Mr. W. M. Mordey remarked during the discussion on the paper, the names Arnold and Elmen are to be associated with a very important advance in electrical communication. The remarkable improvements in the efficiency of telegraphic transmission attained during the past few years must be attributed, as far as the cable is concerned, to the original work of these men. "Permalloy," a nickel-iron alloy, which may be regarded as typical of the new group, possesses the property that whilst with comparatively high magnetising forces the permeability is less, or, at any rate, is no higher, than that of iron, at the lower magnetic intensities it is very much greater. In telegraphic transmission the magnetic force due to the signalling current is only in the neighbourhood of 0·00001 to 0·15 Gauss, but the alloy exhibits the magnetic permeability necessary to fulfil the requirements of high-speed working. The material has also a low hysteresis loss when the magnetising forces and resultant flux are changed rapidly, whilst the resistivity of chrome "Permalloy" used for cable manufacture is as high as 45 microhms per centimetre cube. A high resistivity is essential in order to minimise eddy current loss, and by the addition of chromium, manganese, tungsten or other elements the resistivity of the alloy, consisting of 78½ per cent. nickel and 21½ per cent. iron, can be increased considerably without appreciable detriment to the permeability. In discussing the paper Mr. W. M. Mordey suggested that possibly Sir John Hopkinson unconsciously produced "Permalloy" during his exhaustive experiments on the magnetic properties of iron-nickel alloys. The magnetic properties of these new alloys, however, depends very largely upon the heating and cooling treatment; in fact, prior to the heat treatment the magnetic properties are inferior to those of iron. For the practical manufacture of a loaded conductor it is necessary for the alloy to be in the form of a cylindrical wire or flat narrow tape, produced by a succession of forging, rolling and drawing operations, the ultimate dimensions depending upon the inductance required, and the wire or strip is wound helically round the copper conductor with which it makes contact. On the conductor of the Fanning Island-Fiji portion of the 1926 Pacific cable the loading consists of eighty turns of chrome "Permalloy" wire per inch of conductor, which is 126 mils in diameter, whilst the diameter of the loading wire is only 11 mils.

The descriptions which the authors give of the method of application of the loading material to the conductor and subsequent processes of annealing and testing are of very great interest, and the scarcity of papers on transoceanic submarine telegraph cables since the year 1899 has been more than compensated for by this new contribution. Into all the technical details of these new continuously loaded submarine cables we cannot enter, but the fact should be emphasised that the vast improvements that they have introduced are the result of careful research. It has been computed that a loaded cable capable of transmitting 1000 letters per minute in one direction over a distance of 2000 miles would involve only half the capital outlay needed for a system of non-loaded cables of equal transmitting capacity, viz., 500 letters per minute in each direction simultaneously. When very high transmitting speeds are essential or when greater distances have to be spanned even greater savings would be effected by adopting the loaded type of cable. Thus it is seen how essential it is to foster electrical research. Money spent on work of this nature may easily be repaid many thousands of times and may confer enormous benefits on mankind. That many things associated with electrical engineering are far too complicated and costly and ought to be replaced by something different there can be no doubt. In the heavy branches of electrical engineering, as well as in the branch of electrical communication, there is scope for improvement, and it is to be hoped that the results set forth in this interesting paper will serve to stimulate investigation and minimise the difficulties that some research workers appear to experience in the direction of raising funds.

The Engineering Conference at Tokyo.

ON October 26th we called the attention of British engineers to the important engineering conferences which are to be held in Japan in the autumn of 1929. In that article we alluded to the difficulties which faced engineers from this country in attending these meetings, and expressed an earnest hope that something would be done to overcome them. We pointed out that America was sending no less than two hundred and fifty representatives, many of them delegates of technical institutions, and that some European countries had expressed their intention of being well represented. At that time the response of British engineers to the invitation to attend was very small, and we must admit with regret that even now it is not as large as desirable. However, an important official step has at last been taken, and the importance of the matter is being brought before the members of our leading institutions. On December 10th a conference of engineering institutions and societies was held at the Institution of Civil Engineers to discuss what means should be taken to ensure adequate British representation. As a result a committee consisting of representatives of twenty-three institutions which had accepted invitations to take part was formed. This committee has for its objects (*a*) the formation of a party of British engineers to attend the World Engineering Congress at Tokyo, and (*b*) the securing of a number of papers on engineering subjects for presentation at that Congress. The members present at the conference were unanimous in their desire that Great Britain should be represented on a scale commensurate with her engineering importance, though they recognised the serious obstacle presented by distance. From the main committee an executive was appointed. It comprises Sir Brodie Henderson, Mr. R. W. Allen, Sir John Bi'es, Sir Alexander Gibb, Professor P. A. Hillhouse, Mr. Archibald Page, and Mr. E. F. C. Trench. This committee will have its secretariat at the Institution of Civil Engineers. It earnestly desires that, through their respective institutions or societies, prospective visitors to the Congress in Tokyo will advise it as soon as possible of their intentions, but above all that engineers who are prepared to write papers for submission to the Conference will inform the Committee as to the title and nature of the communications. It is obviously desirable that overlapping of papers should be avoided as far as possible, and the Committee will do its best to prevent that occurrence. Whilst it is hoped that the British attendance in Japan may be large, it is pointed out by the committee that it is not essential that the authors of papers should be present in person. The difficulties connected with a personal visit do not apply in the case of papers, and as there are many engineers in this country well qualified to speak with authority on the subjects which will come before the Congress, we trust that the number of papers and their merit will maintain the position of British engineering and do something to countervail a possible relatively small number of delegates.

Literature.

The Economics of Coal Mining. By Professor ROBERT W. DRON. London: Edward Arnold & Co. 1928. Price 10s. 6d. net.

PROFESSOR DRON has produced a very useful book on a very important subject, and one in which the general public of this country, and more particularly all concerned with any phase of engineering industry, are very intensely interested. His work consists of ten chapters, each devoted to one particular aspect of colliery working, but as the whole volume only contains some 165 pages of text, it need hardly be said that he has been able to do little more than touch upon the fringe of this vast subject, and has left numerous important aspects of it altogether out of his purview. It is to be regretted that he does not appear to have made use of a paper by Mr. Evan Williams on the "Economics of the Coal-mining Industry," presented before the Empire Mining and Metallurgical Congress in June, 1925, which, together with the discussion upon it, gives much valuable information upon the subject of the book.

Professor Dron has been very careful, possibly too careful, to avoid any serious discussion of the labour problems in the coal industry, although that side of the question has an important bearing upon the whole subject. It may be worth while to consider one aspect of it which Professor Dron has not touched upon. He states that under pre-war conditions the capital engaged in coal mining was approximately 10s. per ton, and that at the present date the new capital required for each new ton of annual output is not less than 20s., figures which agree with those given by Mr. Evan Williams in the paper already referred to. Mr. Evan Williams appears to estimate the amount of capital engaged in the coal mining industry as something of the order of 210 million pounds sterling. According to the latest returns, the total number of men engaged in the industry may be averaged at about one million. In other words, coal mining employs a capital of just about £200 for every person engaged in it. Although this sum may not appear large, it is nevertheless fully as much as the industry can bear. It must be remembered first of all that practically the whole of this capital forms a wasting asset; the huge expense of sinking and equipping shafts, opening out and equipping roadways, &c., is all absolutely worthless when the life of the mine has come to an end. The first call upon the profits of a coal mining operation, *i.e.*, of the difference between the selling price of the coal and the cost of producing it, must therefore be the formation of a sinking fund to replace this capital when the mine is exhausted. Opinions differ considerably as to what the annual contribution to such a sinking fund should

be. If it is assumed that the fund can accumulate at 4½ per cent. interest less income tax at 4s. in the £, and that the average life of a colliery is thirty years, the annual contribution to the sinking fund must be 5·5 per cent. on the original capital. In other words, every person engaged in the coal mining industry must be able to earn for the capitalists who have sunk their money in the industry a net profit, as above defined, of £11 per annum, before there is any real profit at all, simply to replace the capital irretrievably sunk in the coal mining industry. This is an aspect of the case that Professor Dron does not discuss at all, and it is one to which attention should be directed, because it is too frequently overlooked.

The difference between an industry based upon a wasting asset and an industry based upon what may be called a permanent asset is very important, and it is not too much to claim that it should be considered the basal principle in the economics of the coal mining industry. It is perhaps one of the greatest defects in Professor Dron's work that he has not laid sufficient stress upon this particular characteristic of the industry. It is, of course, mentioned and referred to as it could not fail to be in any discussion of the economics of coal mining, but it is not given that marked prominence which its supreme importance deserves.

Professor Dron has devoted a chapter, unfortunately all too short, to coal cleaning, but he pays rather more attention to the principles of coal cleaning than to the economics of the subject, and it cannot be pretended that the views which he does put forward will meet with universal acceptance. For example, he considers it an illogical proceeding on the part of the consumer that when trade is good and prices are high he is willing to burn a product with so large a percentage of dirt that it does not pay the coalowner to keep the washer going. The real truth is that when the demand for coal is high the consumer is given no option; he has got to take whatever the coalowner chooses to give him, and be thankful that he gets anything at all that is capable of burning; as one colliery manager has expressed it, at times like these he can sell anything that is black. It is only when the demand falls off that the consumer is in a position to exercise any discrimination at all, and then he naturally favours the coal that is most carefully cleaned and, therefore, the most economical in use.

It may be doubted whether Professor Dron's statement "that the larger sizes are more easily washed and therefore contain less dirt than the smaller sizes" can be generally accepted. It is true in some cases, though by no means in all, with raw coal, but, as a rule, the reverse is true of washed coal; it is possible to wash nuts cleaner than large coal, but, on the other hand, if both are washed, the larger coal will have less water adhering to it than will the smaller sizes, and will, therefore, on this account be more economical in use. Professor Dron gives some calculations showing the cost of washing, and his conclusion that "an all-in cost of 6d. per ton should be regarded as a maximum figure" will probably be endorsed by most experienced coal washers. Unfortunately, however, he omits to take into account what is really the serious money loss in coal washing, namely, the loss of the vend. If 100 tons of coal which might conceivably be sold in the unwashed condition, are washed, an output of 90 tons of clean coal would probably be considered as quite a good recovery. Hence, if the original unwashed coal cost 10s. per ton, the loss of vend in washing will have added 1s. to the cost of coal exclusive of the cost of washing. It is, therefore, evident that this item is by no means a negligible one, adding, in fact, far more to the enhanced cost of the washed coal than does the actual cost of the washing operation.

It may fairly be said that the defects of this little book are mainly defects of omission, inasmuch as Professor Dron has found it impossible within the limits of so small a work to deal with all the multifarious aspects of a very extensive subject. But he has written illuminatingly upon all those points which he has been able to include, and his little book will be welcomed by a wide circle of readers, not only among colliery engineers, but by all who are in any way affected by questions concerning the cost of coal, that is to say, by the vast majority of the population of this country.

Die Werkstoffe für den Bau Chemischer Apparate. By Dr. A. FURTH. Leipsic: Otto Spamer. 1928. Price 20 marks.

THIS volume is one of a series of synoptic treatises on chemical technology. The theme chosen in this case is such as to throw light on the properties of materials from a chemical engineer's point of view. As a matter of fact, the reader will find that he has to deal with an excellent up-to-date treatise on testing of materials from anybody's point of view—in fact, an engineer's text-book on the subject.

The start is made with a description of the ordinary ways of determining tensile strength, resistance to compression, torsion, shearing, impact, &c. &c. Special tests like cement testing, high temperature testing, porosity tests, gas transfusion tests, &c. &c., follow. A particularly useful chapter on heat conductivity is to be noted. All the methods are illustrated with particularly good blocks. As might be expected, considerable space is given to testing of refractory substances. Electrical testing comes next and includes determination of resistances of conductors, insulation resistance, dielectric constant, and everything relating to materials for electro-technical plant.

After these universally adopted methods of testing there is a chapter on testing for corrodibility by estimating dissolution velocities and P.D. between test pieces and mercury. This chapter also includes testing refractories for resistance to molten slags at high temperature.

There is a part devoted to metallography and determination of transition points, followed by one on an X-ray examination of materials.

How all this can be crowded into 71 pages is all the more astonishing, as great attention is paid to detail. There is a very unusual slip on page 57, where the text refers to letters on a Fig. 38, which has been replaced by another, in which the design is altered.

The specialised part of the book treats various materials under separate headings, and these cover a description of mode of manufacture, as well as properties and very often market price. It is astonishing to see how much new, concise information has been collected by the author. Most of us know, for instance, that glass is impervious to gases apart from surface occlusion, but it is somewhat astounding to find that Quincke has kept carbon dioxide and hydrogen in tubes 1·5 mm. thick under 120 atmospheres pressure for seventeen years without any measurable loss! Probably the majority of people would have been satisfied after ten years. Perhaps the best parts of the book are the chapters on glass and ceramic products, in the technology of which the Germans enjoyed until recently an undoubtedly leading position. Still, most of the other chapters contain much of interest and value. In the chapter on rubber it is perhaps not quite unexpected to find that the Germans manufactured synthetic rubber during the war on a large scale, particularly in 1918, but reassuring to read that it was only permissible as a war emergency on account of cost.

As long as he sticks to non-metallic substances the author appears to be in his element, whereas he is somewhat disappointing with regard to metals, probably on account of restriction as to space, besides which the series of books contains special volumes on various metals and alloys. It must not be forgotten that the plan of this book allows of it being expanded to encyclopædic proportions, and that giving due consideration to this fact the author may have found a happy medium. No doubt a book like this one is worth translating, and, maybe, amplifying, if it is going to be useful outside the chemical profession, in which a knowledge of German is almost imperative. There is, however, the query whether a translation of similar typographic merits could be sold at the moderate price of the original. Besides this, there is such a bewildering number of new German publications of this kind, generally of some merit, that a choice is difficult. There is also a marked improvement in the average quality of English technical text-books, although a good many appear and disappear with the first edition of 500 copies. Amongst them have been many of great merit, and the fault is probably to be found in the price and mode of distribution. The publisher of the volume under review could not produce the book to sell at 18s. if the first edition did not contain some thousands. These are distributed, apart from a small number, for sale or return to booksellers, not only in Germany, but over a great part of the civilised world, and returns from one country go to another till the lot is disposed of, or an unsaleable rest remains. Circulating libraries are a secondary consideration, as most decently well-off people in the countries involved buy books as being just as necessary as newspapers. Practically every desirable English text-book can be got in German translation anywhere on the Continent more easily than the original. Many buyers would prefer the English edition, but paying heavy postage on the top of a generally high price is a consideration to a student or even a professor on the Continent. Publishers forget that whatever the market may be for *belles-lettres* in Great Britain, America and the Dominions, the market for scientific books is vastly greater on the Continent as a whole. Widening the market would mean lower prices to students and men of science, whose every requirement, from a pocket lens to chemicals and instruments, is safeguarded beyond their means, as a rule. Moderate prices of good scientific books are the safest indication of the highest state of civilisation, after all. There is a certain humiliation in finding German books of this nature better for the money, though even they cost too much. In one respect, English publishers give better value—they use better paper as a rule. The heavily loaded, glossy paper which Germans, and in particular Americans, employ for the sake of the illustrations, becomes utterly frail after quite a small number of years, and the book reviewed is no exception. Even if it should be antiquated in six months, it gives a fair picture of the state of the art of testing materials at its time, and for this reason alone it ought to possess permanence.

"Les Cycles irréversibles et la turbine Van den Bossche." Paris: Chaleur et Industrie, 5, Rue Michel-Ange.

THIS is a book which we can recommend to collectors of thermo-dynamic fallacies, if such collectors there be. Its thirty-eight pages are devoted partly to a mathematical theory which is supposed to show that it is possible "to transform the kinetic energy of the molecules of warm and boiling liquids directly into motive power," and partly to a description of a turbine by which this desirable end is to be achieved. In the opening sentence is given a mathematical expression signifying that entropy has the same dimensions as kinetic energy, and this extraordinary postulate seems to underly the whole of the reasoning. We will not attempt to expound the latter, for it is not worth the trouble. It must suffice to say that it leads to the conclusion that a turbine can be built which will function without a condenser of any kind, the steam being turned to water in the turbine, and no external "sink" of heat being necessary. According to an entropy-diagram given, the cycle would seem to depend on saturated steam condensing in the turbine by numerous stages along a constant volume line, or rather by a number of zigzags between two neighbouring constant-volume lines, to a condition in which it is almost entirely water. In the author's mind there is some thermo-dynamic virtue in doing this condensation very slowly, taking several seconds about it, in fact, in order to make the cycle more "irreversible."

A separate chapter is devoted to a consideration of five special characteristics of the Van den Bossche turbine. The first characteristic is said to be that all stages are of equal size, since no expansion of the working fluid takes place. The second is the length of time taken by the steam to pass through the turbine as mentioned above. The third characteristic is that the centrifugal force of the steam in each stage introduces "an artificially created source of external cold," so that the turbine works independently of the temperature of the atmosphere or of any cooling water. Fourthly, the steam is cooled "*par voie de la mécanique statistique*," whatever that may be. The fifth and last characteristic of the turbine is that the water of condensation is caused to flow in a direction opposite to that of the working steam in order to assist the effect of the two means of cooling previously mentioned.

It is difficult to find words to express what we really think of this book. The author, however, cannot accuse us of having passed the bounds of legitimate criticism if we quote two sentences of his work, with the suggestion that the name Van den Bossche might with advantage replace that of Doctor Stodola. "En terminant ce chapitre, nous ne pouvons pas nous empêcher de mettre les personnes intéressées en garde contre les monstruosités scientifiques développées d'une façon pathétique dans le livre de Stodola. . . ." "Stodola a prouvé . . . qu'il n'a pas la moindre notion de la signification du premier principe de thermodynamique, et les conclusions auxquelles il arrive sont catégoriquement fausses." A French patent granted for this preposterous invention (No. 610,033 of 1926) is printed at the end of the book. A German patent also seems to have been granted after a four years' wrangle with the examiners about the possibility, of perpetual motion and of a turbine working without a source of cold, although what claims were eventually admitted by the German Patent Office are not stated. Nor, indeed, does it matter.

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Gas and Liquids: A Contribution to Molecular Physics. By J. S. Haldane. London: Oliver and Boyd, 33, Paternoster-row, E.C. 4. Price 18s. net.

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The South American Handbook, 1929. Edited by J. A. Hunter. London: South American Publications, Ltd., Atlantic House, Moorgate, E.C. 2. Price 2s. 6d. net.

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Present-day Developments in Machine Tools. By E. W. Tipple. London: The Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's-square, S.W. 1. Price 2s. net.

Wärmetechnik im Schmiede-, Glüh-, und Härtereibetrieb. By Dr.-Ing. F. Böhm. Berlin: Verkehrswissenschaftliche Lehrmittelgesellschaft, m.b.H., Wilhelmstrasse 87, W. 8. Price 5 marks.

The Measurement of the Discharge of the Nile through the Sluices of the Aswan Dam: Final Conclusions and Tables of Results. By H. F. Hurst, M.A., D.Sc., &c., and D. A. F. Watt. Cairo: Publications Office, Government Press, Bûlâq. Price 10 piastres.

Report on Machinability.*

By E. G. HERBERT, B.Sc., Member.

In undertaking an investigation of machinability of metals, it was necessary to decide on certain limitations within which the inquiry should be confined, and to lay down some general principles for guidance. It was decided to limit the inquiry to machinability by sharp cutting tools, and, as regards the principal part of the inquiry, to the particular form of knife tool generally used on the bar lathe. The principal criteria by which machinability may be judged are three—the speed at which the metal can be cut; the resistance to cutting, usually in terms of force or pressure; and the blunting effect on the tool. It was decided to make use of all these criteria, but only as a check on the conclusions which might be arrived at as a result of the main investigation, the purpose and scope of which was to ascertain the fundamental principle underlying the resistance which a given metal offers to a cutting tool, and to lay down, if possible, a quantitative basis from which machinability might be calculated in terms of speed, feed, and depth of cut. An investigation of so fundamental a character must necessarily begin with a detailed study of the action of the cutting tool under certain predetermined conditions.

The conclusions of previous workers may perhaps be

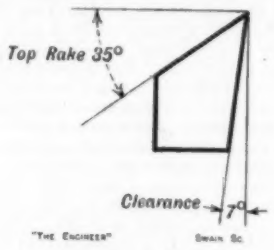


Fig. 1.—*Standard Knife Tool.*

summarised by saying that there exists no general quantitative relationships between the machinability of metals and their tensile strength, hardness, or any other known physical characteristics which they possess. This conclusion has been confirmed and explained by the present investigation. Nevertheless, it has been found possible as a result of this investigation to formulate a simple Law of Machinability, which may serve in future as a quantitative basis for calculations involving that important property of metals.

The principle laid down in selecting the test conditions was that the cutting must be done under conditions actually occurring in the workshop, as nearly as possible. The qualification is necessary because, whilst it is obvious that a true comparison of the machinability of metals could only be made if they were all cut under identical conditions, it is equally obvious that to cut metals so diverse as soft wrought iron, free-cutting steel and 90-ton alloy steel all at the same speed—namely, the speed at which the 90-ton alloy steel could be cut—would not be in accordance with workshop practice. To meet this difficulty a compromise was decided on. Preliminary tests having shown that most of the materials could be cut at a certain lathe speed corresponding to a peripheral cutting speed of 61ft. per minute, it was decided to adopt this as the standard speed, and to reduce it only in those cases where cutting at the standard speed was found to be impracticable, the reduction being made progressively by steps until the highest practicable speed was found. Thus the criterion of cutting speed only entered into those tests which were necessarily made at less than the standard speed of 61ft. per minute.

As a further check on the conclusions which might emerge from the fundamental investigation, it was decided to make experimental cuts on all materials in a hacksaw machine. This type of machine was selected because, unlike almost all other machine tools, it has a permissive feed. It was decided to take advantage of this special feature by making ten cuts through each test bar with a saw blade ground to a standard tooth angle, and recording the number of strokes taken in each cut, the machine being fitted with a revolution counter. Thus the number of strokes required to make a cut would give a measure of resistance to cutting, while the progressive increase in the number of strokes from the first to the tenth cut would measure the blunting effect on the saw.

As it was possible that the cutting action of a lathe tool might vary with the speed, so that cuts made at the speed arbitrarily selected as standard might possess some features peculiar to that speed, a preliminary series of speed tests was made. Cuts were taken at each of the eight speeds with which the lathe was provided, the same test bar being used throughout, and an analysis was made of the chip formation.

Very early in the investigation it became evident that a fundamental inquiry into machinability must involve a detailed study of cutting action, and particularly of the function of the structure known as the "built-up edge." Close attention was given to this subject, and as a result of this study a modified form of cutting tool was evolved and experimented with.

I. Test Conditions and Procedure.

(1) *The Lathe* was a No. 13 bar lathe by Messrs. Alfred Herbert. It has eight speeds, giving on the 1½in. diameter bars used in all tests the following peripheral cutting speeds:—

Lathe speeds ..	A1	A2	A3	A4	B1	B2	B3	B4
Cutting speeds, feet per min. ..	7·45	12·2	18	29	45·5	61	104	165

(2) *The Tool* was of high-speed steel sharpened before each test. As it was desired that the tool shape should be representative of general workshop practice, the late Mr. P. V. Vernon was consulted, and he kindly furnished particulars of a general-purpose tool, as shown in end view in Fig. 1. Mr. Vernon pointed out that the tool angle should be varied according to the material to be cut, but as it was desired to eliminate all variables except the one under investigation, the tool shown in Fig. 1 was adopted as standard.

(3) *The Speed* was 61ft. per minute at the periphery of the test bar in all cases where it was practicable to cut at that speed. If the tool failed immediately, the next lower speed was tried, and if necessary again reduced until the highest practicable speed was found.

(4) *Feed.*—A first series of cuts was made with a feed of twenty-seven turns per inch, but as it was found that on some of the harder steels there was difficulty in driving so heavy a feed, those tests were discarded and a fresh start was made with a feed of fifty-five turns per inch—0·0182in.—which was adopted as standard. This feed gave a chip whose actual thickness was just over 1 mm., which allowed ample room for hardness tests, six abreast if desired.

(5) *The Cut* adopted as standard was ¼in. deep, giving ½in. reduction of diameter. On one or two of the harder steels there was difficulty in driving, and the cut was reduced to ⅛in. or ¼in. This did not affect the investigation of chip formation.

(6) *A Cooling Medium* consisting of water and a standard cutting compound was used in all tests, except in those of cast iron, and all cuts were made with roller steadies supporting the workpiece.

(7) *Test Bars.*—These were all 1¼in. in diameter. The author expresses his great indebtedness to the firms which not only supplied the material free of charge, but gave generous assistance in advising as to the selection of varieties for investigation and in furnishing particulars of chemical composition and physical characteristics. The bars were identified by serial numbers and the initials of the suppliers. It was originally intended to include in the investigation a range of non-ferrous metals, but this was found impossible in the time available. A list of materials investigated will be found in Table I.

Table I.—*Table of Test Bars.*

Bar No.	Description.
1CL ..	Bessemer, annealed
2CL ..	,, normalised
3EA ..	1·2 per cent. carbon steel, annealed
4EA ..	Chrome-vanadium, tempered for machining
5EA ..	Chrome-vanadium, heat treated
6EA ..	5 per cent. nickel steel, case-hardened
8RH ..	Cast iron, hard cylinder (graphite 2·60 per cent.)
9CL ..	Acid open-hearth steel, annealed
10CL ..	Acid open-hearth steel, normalised
11CL ..	3 per cent. nickel steel (Siemens)
12AW ..	Ni-Cr-molybdenum, heat treated
13AW ..	Ni-Cr-molybdenum, heat treated
15BB ..	Stainless steel
16BB ..	,, ,,
17H ..	Manganese steel
18CL ..	S. 11 nickel-chrome, annealed
19CL ..	S. 11 nickel-chrome, heat treated
20CL ..	S. 65 Ni-Cr-molybdenum, annealed
21CL ..	S. 65 Ni-Cr-molybdenum, heat treated
22WTF	Free-cutting steel, "good"
23WTF	,, ,, "bad"
24PG ..	,, ,, "bad"
25PG ..	,, ,, "good"
26LM ..	Wrought iron

AW = Sir W. G. Armstrong, Whitworth and Co.; BB = Brown Bayley's Steel Works; CL = Cammell Laird and Co.; EA = Edgar Allen and Co.; WTF = W. T. Flather; H = Hadfields; LM = Robert Heath and Low Moor; PG = the Park Gate Iron and Steel Company; RH = Ruston and Hornsby.

(8) *Procedure.*—The end of the 1¼in. test bar having been reduced to 1in. diameter and the roller steadies adjusted, the feed was started, and when cutting had become normal the lathe was suddenly stopped and the tool removed from the tool box, great care being taken not to disturb the chip or the built-up edge attached to the bar. It was at first intended to turn at least 3in. up the bar before stopping the cut, but examination of the chip having shown that normal cutting took place after the first 6in. of chip had been formed, it was later decided to stop the cut after turning about 1in. up the bar. The shorter run was adopted because some of the steels could only just be cut at the standard speed. It was desired that all the chips investigated should have been produced with a sharp tool, and this would not always have been the case if the length of run had been extended. The end of the bar with a short length of chip attached was parted off. A small segment with the chip attached was separated with

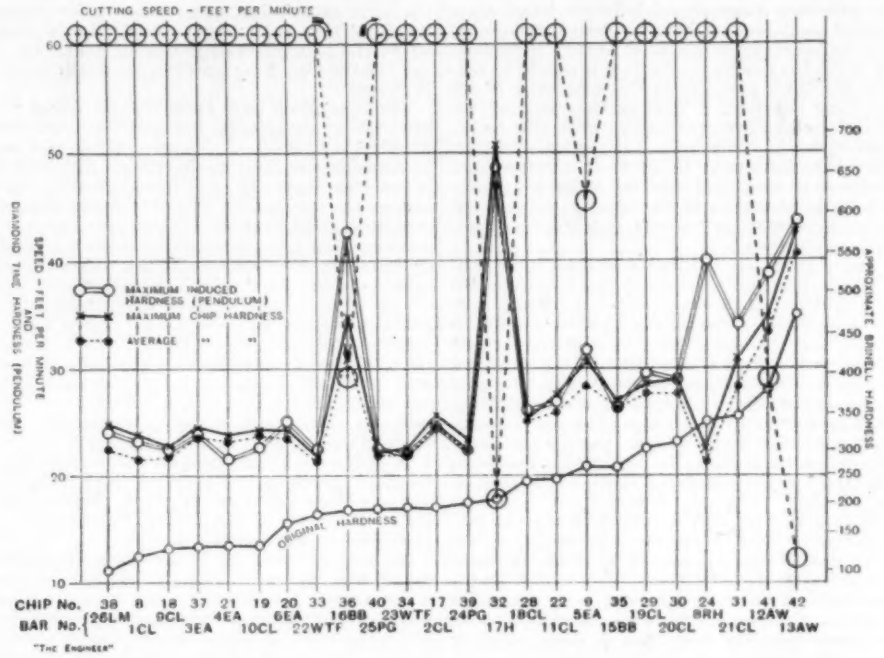

CUTTING SPEED - FEET PER MINUTE
DIAMOND PYRAMID HARDNESS (PENDULUM) AND SPEED - FEET PER MINUTE
APPROXIMATE BRINELL HARDNESS
MAXIMUM INDUCED HARDNESS (PENDULUM)
MAXIMUM CHIP HARDNESS
AVERAGE " "
ORIGINAL HARDNESS
CHIP No. 38 8 18 37 21 19 20 33 36 40 34 17 39 32 28 22 9 35 29 30 24 31 41 42
BAR No. 26LM 9CL 4EA 6EA 16BB 23WTF 24PG 18CL 5EA 19CL 8RH 12AW
1CL 3EA 10CL 22WTF 25PG 2CL 17H 11CL 15BB 20CL 21CL 13AW
"The Engineer"

Fig. 4—*Summarised Results of Lathe Tests; Original Hardness, Induced Hardness, and relative Cutting Speeds.*

Fig. 2—*Temporary Built-up Edge attached to the Chip.*

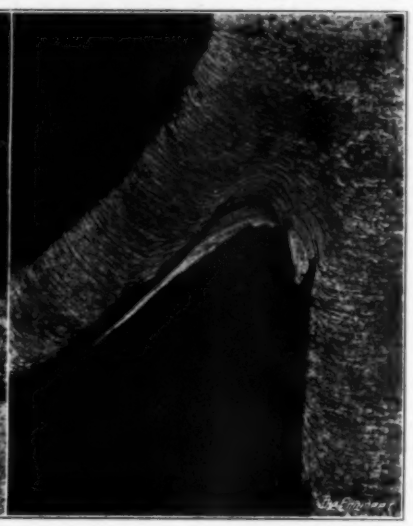


Fig. 3—*Typical Cutting Action of Knife Tool.*

* Institution of Mechanical Engineers. Report to Cutting Tools Research Committee. Abstract.

a hand hack saw. A section was made through the chip and the portion of bar to which it was attached, the section being parallel to the axis of the bar. The section was made by grinding away the outer surface of the bar and chip. The specimen was mounted in pitch contained in a steel ring and was polished by hand on coarse and successively finer grades of emery paper, finally polished with rouge, and etched with picric acid. Hardness tests were made with the Pendulum hardness tester furnished with a 1 mm. diamond ball on the chip and at many points around the zone of the cut. Hardness tests were made on the flat surface formed by the tool just previously to the stopping of the cut. Time work-hardening tests were made with the Pendulum on a part of the specimen which had not been hardened by the action of the tool. In these tests the original diamond time hardness was first measured, the Pendulum was then tilted by hand, first to the right, then to the left, then back to the vertical position, so as to roll out the original circular impression into an elongated form and to work-harden the metal. A second time test was then made on the surface so rolled and hardened, and this gave the hardness induced by two passes of the ball. The process was repeated and measurements were made of the hardness induced by rolling four, six, eight times, and so on until the hardness reached a maximum and began to decline. The test measured three important properties of the metal, its original hardness, its "maximum induced hardness"—this being a measure of its work-hardening capacity—and its rate of work-hardening. The specimen was then photographed under a magnification of 12 diameters.

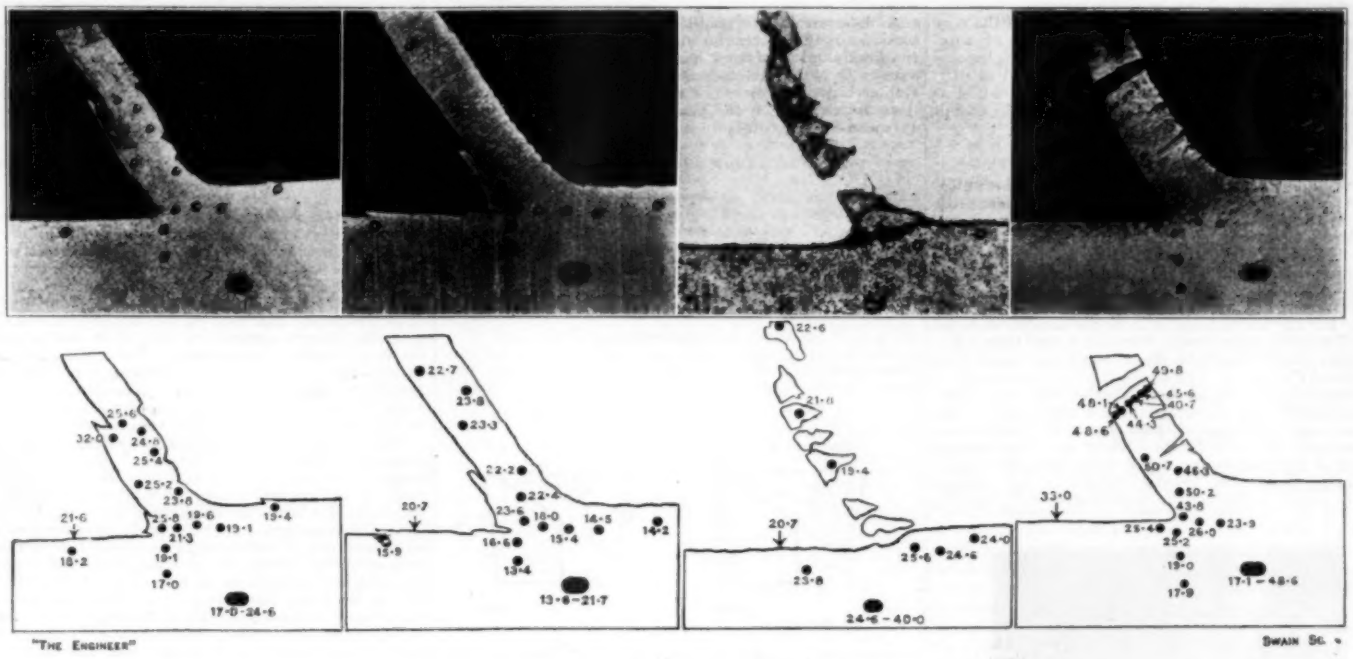


FIG. 5—*Bar No. 2CL.* × 8 dia. FIG. 6—*Bar No. 4EA.* × 8 dia. FIG. 7—*Bar No. 8RH.* × 8 dia. FIG. 8—*Bar No. 17H.* × 8 dia.

II. THE CUTTING ACTION OF KNIFE TOOLS.

In a former investigation by the author a detailed study was made of the cutting action of roughing tools having a top rake angle of 20 deg., and it was found that the implement which actually does the cutting in such cases is not the tool, but the structure known as the "built-up edge," an intensely hard body, roughly triangular in section formed by the welding together of successive layers of material derived from the zone of the cut and deposited on the point of the tool, so as to protect it from contact with the material it is ostensibly cutting. During the first stage in the formation of the built-up edge, a layer of steel is dragged off the underside of the chip through the intense frictional resistance between the chip and the top surface of the tool over which it is constrained to flow. This thin layer separates itself from the chip and attaches itself to the tool, and a second layer, similarly formed, welds itself on the top of the first, this process being repeated until the complete edge is built up of innumerable layers welded together. The cleft running ahead of the tool which has taken a prominent place in the literature of cutting tools, appears to be a feature peculiar to the commencement of cutting. It has not been observed in cuts which have continued for any length of time. The built-up edge appears to be a permanent and self-renewing structure. It is constantly worn away by the action of cutting; but whenever its efficient cutting shape is impaired by wear, intense local pressure is set up, which results in a patch of metal being dragged out of the bar or chip and welded on, so as to restore the normal cutting angle.

In cuts made with acute angle knife tools the built-up edge is almost universally found, but it is no longer a permanent structure protecting the edge of the tool. Owing to the steep slope of the top face of the tool, the built-up edge is not able to find a permanent resting-place, but slips off the tool as soon as it has been formed. It is carried away by the chip, from which it has never become completely detached, and can be seen as a series of ridges on the underside of the chip. One of these temporary edges is seen attached to the chip in Fig. 2. A careful computation was made in the case of this cut, and it was found that the temporary edges were formed and discarded not less than fifty times a second. The action is one of very rapid fluctuation, and the structure of the edge is continuous with that of the chip, as first pointed out by Rosenhain and Sturney. Not infrequently a semi-permanent built-up edge is formed, and temporary edges are formed and slip off the back of it, but it is soon carried away by the chip. Fig. 3 shows a typical case of chip formation by knife tools. The highly distorted metal just ahead of the tool separates into two parts, of which the larger is deposited on the chip in a series of ridges, often of fairly even pitch, whilst the other part forms a similar series of ridges on the surface of the bar.

In only two of the cuts made in the present research was a permanent edge found attached to the tool.

III. EFFECT OF SPEED ON CHIP FORMATION.

The cutting speed of 61ft. per minute having been adopted as standard for all test bars which were capable of being cut at that speed, it was deemed advisable to make a preliminary cut at each of the eight speeds with which the lathe was provided, the purpose being to ascertain the effect of speed on chip formation. All cuts were made with the standard tool—Fig. 1—feed 55 per inch, depth of cut ¼in. on annealed mild steel bar 1CL. At the highest lathe speed, driving difficulties occurred, the lathe slowed down considerably, and the actual cutting speed at which the chip was made could not be measured.

In addition to the usual hardness tests a computation was made of the percentage thickening of the chip compared with the theoretical or undistorted thickness which

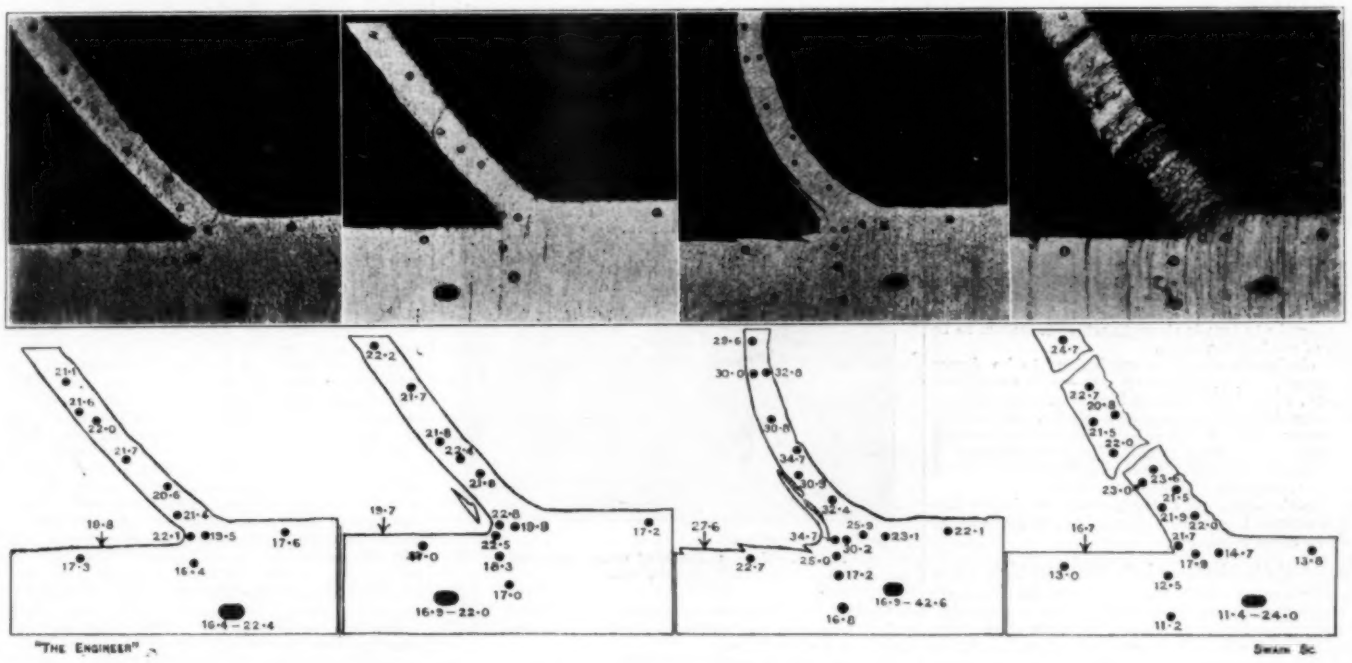


FIG. 9—*Bar No. 22 WTF.* × 8 dia. FIG. 10—*Bar No. 23 WTF.* × 8 dia. FIG. 11—*Bar No. 16BB.* × 8 dia. FIG. 12—*Bar No. 26LM.* × 8 dia.

would be equal to the feed, 1/55in. or 0·46 mm. The actual chip thickness was measured on the photograph, and it was found that at the standard speed of 61ft. per minute the amount of distortion judged by the thickening of the chip, 63 per cent., was less than at higher or lower speeds, whilst the average hardness of the chip was also least at the standard speed. At the three lowest speeds, 7·45ft., 12·2ft. and 18ft. per minute, the chip formation was abnormal, there was no built-up edge, and the chip was segmented in a manner not found in any other cuts.

The conclusions drawn from these speed tests are that any study of chip formation at very slow speeds can give no guidance as to what occurs under normal conditions, in the same way that a study of chip formation at the very commencement of cutting gives no indication of what occurs when cutting has continued long enough to become normal. Cutting at the selected standard speed of 61ft. per minute was quite normal, and the chip formation at that speed showed no special characteristics, except minimum chip distortion.

IV. Machinability.

The results of the fundamental machinability investigation are plotted in Fig. 4, the specimens in that figure being placed in the ascending order of their original hardness. The micro-photographs of some of the resulting chips are shown in Figs. 5 to 13, together with the corresponding hardness charts. All hardness tests and work-hardening tests were made with the 4 kilos. Pendulum hardness tester equipped with a spherical faced diamond of 0·5 mm. radius. For the convenience of those not familiar with the diamond time-hardness scale, conversion has been made into approximate Brinell hardness numbers in a scale to the right of Fig. 4.

An inspection of the hardness charts—Figs. 5 to 13—must inevitably lead to certain definite conclusions. The first and most important of these is that the tool always work-hardens the steel before cutting it. The original hardness of the steel has no significance, and can have no significance, in relation to machinability, since original hardness does not exist in the metal machined; and the

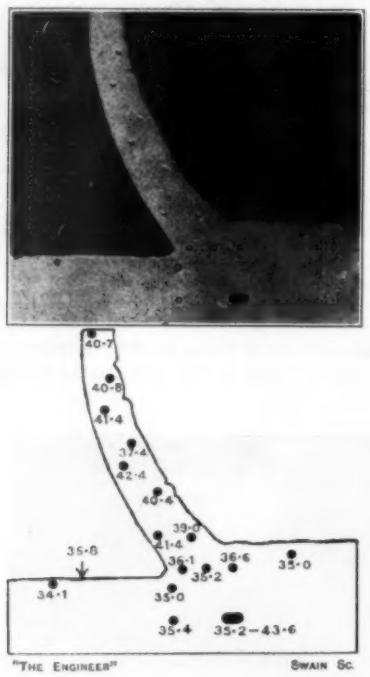


FIG. 13—*Bar No. 13.4 W.* × 8 dia.

same must apply to tensile strength which is known to be a function of original hardness.

Equally obvious are certain conclusions to be drawn from the graph, Fig. 4. In every case—with one exception, namely, that of cast iron—a high maximum induced hardness coincides with a high chip hardness, and in every case without exception a high chip hardness coincides with a low permissible cutting speed. Original hardness is seen to be quite unrelated to maximum induced hardness, chip hardness, or permissible cutting speed.

These considerations lead to the formulation, for the first time, of a simple Law of Machinability, which can be expressed in these words:—

The Measure of Machinability is the Hardness of the Chip.

Chips may vary in hardness according to the character of the tool which produced them, but so does machinability vary with the tool. Thus, stainless steel 16BB was not hardened up to the maximum of which it was capable. This is in accordance with workshop experience in cutting stainless steels. It has been found that they can be cut with least difficulty if an acute angle tool is employed, as in the present instance. An obtuse angle tool would harden the chip more. The harder the chip, the lower the machinability and the lower the cutting speed, as seen in Fig. 4. The Law of Machinability takes account not only of the characteristics of the metal, but also of the machining process.

In measuring chip hardness as a quantitative guide to machinability, it is suggested that a surface should be prepared on the edge of the chip, not on the flat. Six hardness tests were made across the edge of the manganese steel chip—Fig. 8—to ascertain whether any hardness gradients existed, and it was found that the centre of the edge was less hard than the inner and outer surfaces, which, moreover, are often in a burnished or corrugated condition unsuited to a reliable hardness test.

According to the Law of Machinability, cast iron should be the easiest metal to machine, its average chip hardness being only 21·3, which is actually lower than that of any other test bar. This indication of machinability was proved to be correct by the sawing tests described in Section VI. The measurement of the hardness of cast iron chips does not present any insuperable difficulty, but in general it will be unnecessary, as the hardness of the chip varies only slightly from that of the casting. It should be borne in mind that although cast iron is not work hardened by a sharp and efficient tool, it may be hardened by a less efficient one. It is well known that cast iron may be so work-hardened by a blunt hack saw as to be rendered incapable of being cut.

A measure of machinability even simpler than chip hardness is the maximum induced hardness measured by the Pendulum time work-hardening test. This quality is seen to be closely related to chip hardness, and it gives a similar but more general measure of machinability as it does not depend on the particular form of cutting tool. It is also easier to measure than chip hardness. It cannot,

FIG. 14.—*Truncated Tool.*

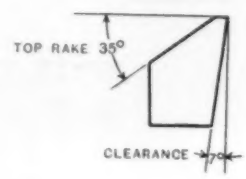
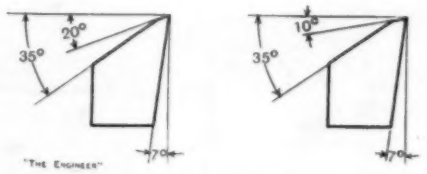


FIG. 15. FIG. 16.

Compound Tools.



of course, be applied to ascertain machinability in the case of metals and machining conditions which do not produce work-hardened chips.

V. Truncated and Compound Tools.

The observations detailed in Section II. of the essential differences between the cutting actions of obtuse-angle and acute-angle tools, led to the inquiry whether it might not be possible to devise a form of tool which should combine the advantages of both, that is, the free-cutting properties of the acute tool, with the faculty of acquiring a permanently protective built-up edge possessed only by the tool of obtuse angle.

The tool forming the subject of the present inquiry is shown in Figs. 14, 15, and 16.

The process of preparing the tool consists simply in grinding a small flat on the top face of the tool at a more obtuse angle than the main top rake. All the tool forms can be ground without any difficulty whatever, either by hand or on an automatic grinder, the extra grinding time being insignificant. All the tools had a principal top rake

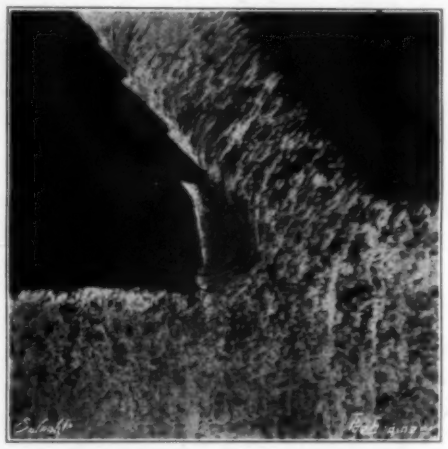


FIG. 17—*Cutting Action of Compound Tool. 35°/10°/0·42 mm.*

of 35 deg. Secondary rakes were ground at 0 deg., 10 deg. and 20 deg., and the widths of the flats so formed varied from 0·4 mm. to 2 mm.

The conclusions drawn from these experiments are that when the truncated or compound edge has a width of more than 0·5 mm. the resistance to cutting and the generation of heat are increased. There is also distortion and undue hardening of the chip. With truncated or compound tools, 35 deg., 0 deg., 0·4 mm.; 35 deg., 10 deg., 0·4 mm.; and 35 deg., 20 deg., 0·4 mm., no such extra resistance occurs. The cutting action and the character of the chip are quite normal, and indistinguishable from those obtained with ordinary tools: but a permanent built-up edge is formed, of characteristic layered structure. This built-up edge is hooked over the edge of the tool—Fig. 17—so as to protect it completely from contact with the work. Temporary built-up edges are formed and slip off the back of the permanent edge exactly as they do from an acute-angle tool of the ordinary form, and the direction of flow of the chip is such that it does not come into contact with the tool, even after leaving the permanent built-up edge. With the 35 deg., 20 deg., 0·4 mm. tool, the built-up edge appears to be less permanent in character, with a tendency to slip off the tool. The best results appear to be obtained with the 35 deg., 10 deg., 0·4 mm. tool. It would appear that apart from the slight amount of wear which must take place in starting the cut, *i.e.*, before the permanent edge has been built up, such a tool would continue cutting indefinitely and would never become blunt.

Whether the principle of the compound tool can be applied to roughing tools for heavy centre lathe work is a question that has not been investigated. It is generally supposed that roughing tools must be ground to somewhat obtuse angles in order to give them strength to resist the heavy vertical force and to provide adequate section to conduct away the heat. For these reasons the compound tool may be found inapplicable to heavy roughing work; but it should be pointed out that the acute angle would tend to reduce both the vertical force and the evolution of heat, whilst the compound tool would acquire a permanent built-up edge completely protecting it from the rapid blunting which would take place with an acute edge of the ordinary form. It is proposed to make the compound roughing tool the subject of further investigation.

VI. Sawing Tests.

In order to obtain a further measure of machinability, and to check the conclusions arrived at in the preceding sections, ten cuts were made through each test bar on a power hack saw machine, the number of strokes taken in each cut being counted.

The Machine.—This was a "New Rapidor" machine of 6in. capacity and 6in. stroke, fitted with three-speed gear, and with a counter operated from one of the slide bars. Preliminary tests having shown that all the test bars could be cut at a speed of 94 strokes per minute, this speed was adopted for all cuts. A cooling medium consisting of water with washing soda in solution was used on all bars except cast iron, which was cut dry.

The Saw Blade.—The whole of the cutting was done with a single saw blade of the "Rapidor" type of 18 per cent. tungsten high-speed steel, and provided with the Evans patented set extending into the body of the blade. This set allows the blade to be sharpened repeatedly without loss of side clearance. The blade was sharpened on an automatic saw blade grinding machine before the commencement of cutting on each test bar. The teeth were automatically sharpened to a top rake 0 deg.—the front face of the teeth being at right angles to the axis of the blade—and a clearance angle of 32 deg.

Procedure.—The speed and dashpot adjustment having been checked and the counter read, the machine was started and the saw frame allowed to fall under control of the dashpot. The counter was put into gear as the saw came into contact with the work, and was thrown out of gear on the completion of the cut. Ten cuts were made through each bar, and in several instances the first cut with the newly sharpened blade took a few more strokes than the second cut. It was therefore decided to take the number of strokes in the second cut as the measure of machinability, and to take the difference between the number of strokes in the second and tenth cuts as the measure of blunting. In several instances this difference was negative, that is to say, the tenth cut was made in a few less strokes than the second. This gain in rate of cutting is attributed to the "built-up edge" phenomenon referred to later. The results of the sawing tests are plotted in Fig. 18.

Referring to the middle curve in Fig. 18, this is seen to confirm generally the curves of chip hardness in Fig. 4. It is clear that machinability, judged by resistance to sawing, is unrelated to the original hardness of the metal. The most difficult steels to saw are the soft stainless steel 16BB and soft manganese steel 17H, which could not be cut with the saw. Both these steels had an abnormally high chip hardness and induced hardness.

The easiest of all the test bars to saw was the cast iron 8RH, which had a high original hardness, a very high induced hardness measured with the Pendulum, but whose chip hardness was lower than that of any other test bar. Thus, cast iron conforms with the Law of Machinability.

Certain anomalies appear, the most interesting of which are shown by the Bessemer steel bars 1CL and 2CL. These bars were of the same steel, but 1CL was in the annealed state and was the softest of all the steels, while 2CL had been normalised and was much harder. The softer bar not only took longer to cut than the harder, but had a greater blunting effect on the saw.

In this connection particular interest attaches to a remark made by Sir Henry Fowler in discussing the author's "Report on Cutting Temperatures" in 1927. Sir Henry Fowler said that "in his own works they always heat-treated nuts in order to cut them freely." In the present case the normalised steel cut more freely and damaged the tool less than the softer annealed steel.

In order to investigate this matter further, a microscopic examination was made of chip formation in sawing. The machine was stopped in the middle of a cut and sections were made through the chips which were found attached to the bottom of the cut when the saw was lifted out. These sections provided the explanation sought for. On the hack saw, as on the lathe, cutting is not done by the tool, but by the built-up edge. The efficiency of the cutting action depends less on the "artificial" cutting angles imparted to the tool by the workman than on the "natural" cutting angles of the built-up edge which actually does the work. Comparing the cases of the annealed and normalised mild steel bars 1CL and 2CL it was found that the "natural" top rake angle of the built-up edge was in the case of the annealed steel 6 deg. This gave inefficient cutting, great distortion and probably great work-hardening of the metal, and short chips nearly at right angles to the cut surface, and consequent high resistance to cutting and damage to the tool. In the case of the same steel in the normalised condition the "natural" top rake angle of the built-up edge was 26 deg. This gave efficient cutting, a free-flowing curled chip with little distortion, slight resistance and little damage to the tool.

The same principle is illustrated by the case of the chrome-vanadium steel 4EA. There was no distinguishable built-up edge, the action was less one of cutting than of pushing the metal off in irregular lumps, there was great distortion, great resistance, very slow cutting, and considerable damage to the tool. When cut on the lathe with an acute-angle tool, this steel was cut at the standard

speed with normal chip formation, and the usual temporary built-up edge. The chip hardness was, however, notably higher than the maximum induced by the Pendulum, as mentioned in Section IV. The same steel treated to a greater degree of hardness, bar 5EA, offered a much lower resistance to sawing, and had an abnormally low blunting effect on the saw; but judged by the lathe tests—Fig. 4—the harder bar 5EA showed a low machinability, and could only be cut at a reduced speed.

The principle is still further illustrated by the hack-saw chip in wrought iron 26LM. In this case the "natural" top-rake angle of the built-up edge is no less than 52 deg. The cutting done by this very acute natural tool of only 38 deg. cutting angle is highly efficient, as shown in Fig. 18, the strokes per cut being lower than for any test bar except cast iron, and the blunting effect in eight strokes zero. Wrought iron is usually regarded as a difficult metal to cut by the hack saw, probably because of its tendency to clog the teeth of the saw. The blade used in the present tests had ample clearance and coarse pitch—six teeth per inch—which accounts for its freedom from clogging. The same type of saw has been found to give efficient service in cutting pure aluminium, another metal with a bad reputation with regard to machining.

The discovery here disclosed, of the all-important *rôle* played by the built-up edge, not only in cutting with roughing tools of somewhat obtuse angle, but also when cutting is done with acute-angle knife tools, and with right-angle saw teeth, throws light on the whole subject of "the art of cutting metals." It explains how tools of such apparently inefficient form as taps, screwing dies, broaches, saws, and milling cutters, are in practice capable of highly efficient cutting. It may explain the anomaly that in a series of cuts with a saw there was in some cases a progressive increase in the rate of cutting

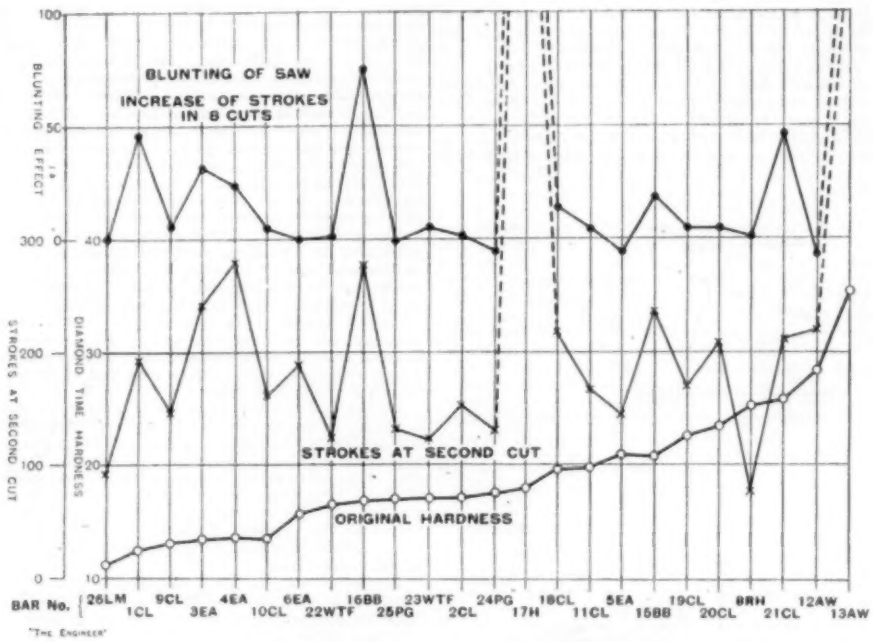


FIG. 18—*Machinability Measured by Rate of Sawing and by Blunting of Saw.*

measured by the number of strokes per cut. There can have been no negative blunting effect, but there may have been a slight alteration in the tooth shape, rendering it more favourable to the building up of an efficient "natural" cutting angle. It is significant that the progressive decrease in strokes per cut was most marked in the second hardest of all the specimens, the 80-ton steel 12AW. In this case the tenth cut actually took six fewer strokes than the second cut—Fig. 18—and thirteen strokes fewer than the first cut with the perfectly sharp saw.

Reviewing the investigation as a whole, it seems to have established a principle of general application. Machinability is not an attribute of a metal, but of a metal and a machining process. A change in the conditions of the machining process may entirely change the relative machinability of metals, and for purposes of quantitative measurement machinability cannot be stated except in relation to the particular machining process to be employed. The Law of Machinability depending as it does on chip hardness, takes account of both the characteristics of the metal and the character of the machining process. The hardness of the chip depends on the capacity of the metal to become harder as a result of distortion, and on the degree of distortion produced in cutting it.

As a practical workshop test of machinability, something may be said for the power hack saw with permissive feed and with a standard sharpened blade. It has advantages over the loaded drill sometimes employed to measure machinability, since this requires special equipment, and the penetration of the drill depends largely on the peculiar action of the drill point, which is not strictly a cutting action. The sawing test is quickly applied, requires no special equipment, and depends on a true cutting action. It is capable of measuring both the resistance to cutting and the blunting effect, and may give valuable information on both subjects. Caution is, however, necessary in applying information derived from this or any machining process to determine machinability under dissimilar cutting conditions.

CONCLUSIONS.

(1) Machining processes change the physical properties of metals to which they are applied. No quantitative relationship can therefore exist between the machinability of metals and the physical properties which they originally possess, and which have not been changed by machining.

(2) Since metals differ in their capacity for being hardened by deformation, and machining processes differ in respect of the degree of deformation they produce, machinability is not an attribute of metals which can be considered or measured apart from particular machining processes.

(3) The hardness of the chips removed by a metal-cutting process indicates the hardness induced in the metal by that process. It takes account of both the characteristics of the metal and the character of the machining process, and is a measure of machinability.

(4) The original hardness of metals gives no indication of machinability. The maximum induced hardness measured by the Pendulum work-hardening test gives a general indication in the case of ductile steels, but none in the case of brittle metals, such as cast iron, which are separated without deformation of structure.

(5) No quantitative relationship exists between the speed at which a metal can be cut, the resistance it offers to the cutting tool, and its blunting effect on the tool. A general correspondence has been found, but subject to important exceptions.

(6) In metal-cutting operations, whether conducted with acute-angle or obtuse-angle tools, the actual cutting is done by the built-up edge which begins to form immediately on the commencement of cutting. The efficiency of the cutting process, and therefore the machinability of the metal depends on the natural angles of the built-up edge rather than on those of the tool which serves to support it.

(7) Very soft steel offers greater resistance to cutting and has a greater blunting effect on the tool than similar steel which has been made harder by heat treatment. This may be attributed to the less efficient natural cutting angles of the built-up edge formed in cutting the softer steel. Highly efficient natural cutting angles have, however, been found, and highly efficient cutting obtained, in soft wrought iron.

(8) The edges built up on acute-angle tools are of a temporary or semi-permanent character, being formed and discarded as often as fifty times per second in some cases. Obtuse-angle roughing tools, when used in continuous cutting, form permanent built-up edges composed of many layers welded together and firmly attached to the tool. Obtuse-angle tools used for intermittent cutting, such as saw teeth, form built-up edges which are generally temporary. They may be fully formed in one-tenth of a second or less, and are generally discarded and built up afresh at each stroke of the saw.

(9) Acute-angle tools may be caused to form permanently protective built-up edges by grinding them to a truncated or compound angle shape. The obtuse-angle which is to retain the permanent built-up edge should not extend more than 0·5 mm. back from the tool edge.

(10) A power hack saw with permissive feed and a standard sharpened saw blade provide a convenient means of measuring machinability in the workshop. Caution must, however, be exercised in applying results obtained by this or any other cutting process to cutting operations in which the conditions are dissimilar.

EXHIBITION OF THE PHYSICAL AND OPTICAL SOCIETIES.—The nineteenth Annual Exhibition of the Physical and Optical Societies is to be held on Tuesday, Wednesday, and Thursday, January 8th, 9th, and 10th, 1929, at the Imperial College of Science, Imperial Institute-road, South Kensington, and will be open in the afternoon from 3 p.m. to 6 p.m., and in the evening from 7 p.m. to 10 p.m. Over eighty firms have accepted the invitation to exhibit in the Trade Section at this Exhibition, and, in addition, a group of research and experimental exhibits is being arranged. It will be shown by Fellows of the Societies and others, and a number of research laboratories and other institutions. Some interesting historical exhibits will also be included. The discourses, which will be given at 8 p.m. on each evening, are as follows:—On January 8th, Professor F. Lloyd Hopwood, M.A., F. Inst. P., "Experiments with High-frequency Sound Waves;" on January 9th, Mr. Conrad Beck, C.B.E., "Lenses;" on January 10th, Mr. A. J. Bull, M.Sc., F. Inst. P., "Some Colour Problems in Photo Engraving."

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

STANDARDISED ENGINE TESTING APPARATUS.

SIR,—I am very much interested in your correspondence on this subject.

To the inspecting engineer the testing and passing of tests of oil engines, at the works of the maker, present many difficulties. Fuel can be readily weighed by quite simple methods. In fact, the more primitive the methods, the easier they are to verify. Cooling water and lubricating oil measurements are of little value, as with a new engine the normal conditions are not obtained.

The measurement of the power developed, if the engine is not driving a dynamo, or alternator, is most difficult to verify. One is generally introduced to a hydraulic dynamometer, which has certain constants stamped on its name plate, and a maker's certificate is produced. If the power cannot be ascertained electrically, it may be necessary to obtain a certificate from the makers of the dynamometer of a verification made specially for the particular test.

Electrical measurements are quite simple, but one can hardly expect an engine maker to have an elaborate electrical testing plant.

I agree with Sir Ernest Petter that the question is a most important one. H. RAVENSHAW, M. Cons. E.

Westmorland, December 17th.

BELT DRIVES.

SIR,—Herr Schubeler's letter in your issue of 14th inst., whilst interesting, does not answer the clear cut question that I asked, viz.:—What precisely is the patentable novelty in the "Lenix" drive? Now, whilst all that he says is perfectly true, it is all knowledge that has been available for many years past, and open to all to use. It is scarcely necessary to say that any apparatus put forward by Messrs. Sulzer will bear the mark of careful design and neat construction, but they are not unique in that way. Good design and neatness are not, as far as I know, patentable. The permanent stretch of a belt as distinguished from the temporary stretch due to the "power-pull" on the tight-side can easily be taken up by other means than the "Lenix" arrangement. Naturally, when the load comes on, the tight side stretches and the slack appears as increased sag on the slack side.

The amount of this can be estimated and allowed for in the case of a fixed jockey pulley—adjustable when necessary by screw gear or otherwise—or it can be taken up automatically by a weighted and movable pulley as described by a correspondent in your issue of 7th inst. Changes due to weather, &c., and knowledge of the characteristics of the belting used, size of pulleys, &c., are all points that have to be taken into account in designing any belt drive, jockey and short belt, or otherwise.

GEO. T. PARDOE.

Sussex, December 15th.

AIRSHIP "R 101"—ZINC-CADMIUM SOLDERS.

SIR,—Mr. J. D. North is not justified in asserting that I threw suspicion on the type of joint he is using. I have never had occasion to form an opinion on this type of joint, and I have never expressed any opinion on this type of joint.

In the final paragraph of his letter (THE ENGINEER, December 14th, page 667), he asks me to make clear the curious obscure defects of these alloys, but in my final paragraph I was careful to divide the defects into the curious and obscure. If the obscure could be made clear, they would not be obscure, and in regard to the curious, I am writing to his company to-day.

H. S. ROWELL, Director of Research,
R.A.B.M.A.M

Chiswick, W. 4, December 17th.

SIXTY YEARS AGO.

WE have dealt in these notes on two recent occasions with the Heaton process for making steel by adding nitrate of soda to a charge of molten pig iron, the object being to provide by the decomposition of the nitrate the oxygen which Bessemer in his process obtained from the air. In our issue of December 18th, 1868, we find reprinted a letter by Bessemer criticising Heaton's process, and a reply from Heaton traversing and denying Bessemer's criticism. Bessemer alleged that the material given by the Heaton process was not homogeneous cast steel but consisted of spongy porous metal intermixed with slag and scoriæ. If hammered and rolled into bars Heaton's metal, according to Bessemer, resembled puddled iron or puddled steel, but to convert it into homogeneous cast steel it had to be remelted in crucibles. It was true Bessemer admitted that the Heaton process had the advantage of being applicable to cheap pig irons containing phosphorus and sulphur, but it could only yield homogeneous cast steel comparable with Bessemer metal at the expense of 36s. a ton for the nitrate required and £5 to £6 per ton for the subsequent remelting process. Heaton in his reply accused Bessemer of criticising his process without taking the opportunity open to all of visiting Langley Mills, near Nottingham, for the purpose of seeing it being carried out. He claimed that his metal without being remelted was homogeneous cast steel, that the slag produced was light and of extreme fluidity, that the oxygen

liberated combined with the carbon in the pig iron and maintained the charge in the fluid state just as long as did the heat supplied by the corresponding combustion which took place in the Bessemer process, and that the product was free from slag or scoriæ. He further accused Bessemer of overstating the cost of the nitrate required, but his most serious charge was his allegation that in introducing the question of remelting the steel Bessemer must knowingly have been attempting to mislead the public. Crucible melting, Heaton wrote, was applied to his metal just as it was to Bessemer's to convert it into tool steel. For his crucible tool steel Heaton was at the moment obtaining £50 a ton. Commenting on the letters, we remarked that it was very misleading of Bessemer to imply that he obtained his oxygen cheaply from the air in contrast to Heaton, who supplied it by means of an added chemical. Those who had put up and used a Bessemer plant, we wrote, knew that the oxygen was obtained at considerable expense in the shape of the costly steam engine and blowing apparatus required to furnish the air blast. We farther remarked that Bessemer in his letter did not disclose a certain very interesting fact, namely, that since the date on which Heaton's process had first been heard of Bessemer himself had secured three patents for the use of nitrates in the manufacture of steel, and had copied Heaton's ideas as closely as he dared, and in the opinion of some people a little closer than was safe or honourable. In a succeeding issue a correspondent, roused by Bessemer's attack on Heaton, quoted counsel's opinion, given to him privately, that Bessemer's patent was in peril on the ground that in his patents of October and December, 1855, he had claimed the use of air or steam, that steam would not act, that he had never entered a disclaimer with respect to the use of steam, that in February, 1856, when he claimed the use of air alone he was in fact re-patenting part of a previous patent, and that this procedure made his patent invalid in law.

All-Welded Petrol Storage Tanks.

ELEVEN petrol storage tanks have recently been erected by the Commonwealth Oil Refinery Company of Australia, the construction in all cases being welded throughout. These tanks are of the following dimensions :—Three are 60ft. diameter by 34ft. 9in. high ; six are 42ft. diameter by 34ft. 9in. high ; and two are 20ft. diameter by 16ft. high. The tanks were expressly designed for welding and large plates were specified to reduce the number of seams to the minimum. The thickness of the plate used varied from ¼in. to ⅜in., the plates used for the tops being ¼in. thick while 3in. lap joints were employed throughout. The principal features of these tanks are that the roofs, which are flat, are water cooled, and erection was carried out without any holes for service bolts.

An ingenious method was devised for welding the tank bottom plates, and here it should be mentioned that the bottom was erected complete on the ground before the structure of the tank was begun.

To facilitate the welding of the tank bottoms six wedge-shaped wooden frames, long enough to accommodate the width of two plates and spaced about 10ft. apart—see Fig. 1—were built. These frames, as will be seen, allow access to the joints from underneath, and after welding are pulled away by means of a winch, the plates falling into position on the sand. Both the longitudinal and transverse seams were welded while on these platforms. The underneath welding comprised simply tack welds about ¼in. long and 8in. apart. When the welding was completed on the top side, an irregular-shaped bottom was finally produced—see Fig. 2.

On this a preliminary line, 3in. greater than the radius finally required, was made and the plates were cut to this line with an acetylene flame. The allowance was a precautionary measure in case difficulty was encountered in getting the bottom side plates down to the base. If difficulty was experienced, the method adopted was as shown in Fig. 3.

The foregoing method of welding the tank bottom was quicker and cheaper than that employed in riveting, where the bottom has to be built up on trestles to allow the holders-up to work underneath, and the whole of the bottom is then lowered by a system of jacks.

The method of erecting the sides was similar to that adopted by the Metropolitan Gas Company, Melbourne, in the case of the Fitzroy holder, which has already been described in these columns, with one exception. In the present case two rings of service angles at the horizontal seams were used in lieu of wooden props. These angle rings were provided with means of bringing the plates together, and the sketch—Fig. 4—shows the detail.

The construction and assembly of the top of the tank does not call for any detailed comment, except that no angle ring was provided for. Steel joists, 6in. by 3in., were used for the trusses and struts, tie rods being used to secure the necessary levelling under load. The side plates were arranged so that the horizontal downward welds were on the outside, and all overhead welds on the sides were made continuous to secure oil tightness. All the horizontal seams on the sides, full fillets being provided for, were completed before the vertical lap welds were made. Those seams joining the tank top plating, and also the bottom plating to the tank side were made after the top, bottom and sides were completely welded.

It was found possible to simplify and quicken the construction of the tank floors by welding the plates—¼in. thick—on the top side only, thus eliminating the necessity for employing the inclined trestles on subsequent tanks, as already described. This was effected by merely pulling the plates into place on the sand foundation, which is confined by a concrete kerb ring, where they were kept flat in position by placing over them a number of rolled steel joists, which were used later for carrying the roof. The floor plates were held up to the joists by means of small service dogs and wedges—see Fig. 5—and the whole floor securely tack welded together, after which the joists were removed and the welding of the seams completed.

A simple form of timber shear legs was employed to hoist the plates into position. The base frame was pivoted at the centre and provided with two small wheels on the outer end to move round the tank.

The whole of the fabrication and erection was carried out without the use of expensive machinery, shops, or machine tools of any description, the plates being lifted into position and welded just as delivered from the mill and shipped to the site without previous preparation. The only plant employed consisted of a welding set, a crab winch, timber shear legs which were built upon site, and oxy-acetylene torches. Even the latter might have been dispensed with and the floor plate cut with the electric arc.

Erection of the tanks was commenced in June of last year. The three tanks, 60ft. diameter, and two of the 42ft. diameter tanks were completed by November 15th, and two other 42ft. diameter tanks were completed by November 30th. Two of the 60ft. diameter tanks were erected in four months by two welders and a foreman, with four ironworkers as assistants. The shell of one tank was erected and tack welded in nine working days. The approximate weight of the steel in each of the 60ft. diameter tanks is 90 tons, and in the 42ft. diameter tanks 46 tons. Their capacities are about 600,000 and 300,000 gallons respectively.

The tanks proved to be tight on the first test, which was carried out in each case by filling with sea water and allowing to stand for two weeks. This constituted a 40 per cent. overload and was therefore considered an adequate test.

The electric arc process and Quasi-Arc electrodes were used throughout this work. Since the completion of this batch of tanks, the contractors, Robert Bryce and Co., Ltd., of Melbourne, have received instructions to proceed with twenty more oil storage tanks.

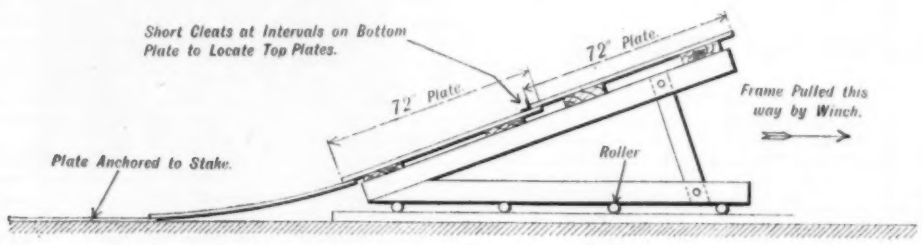

Short Cleats at Intervals on Bottom Plate to Locate Top Plates.
72' Plate.
72' Plate.
Frame Pulled this way by Winch.
Plate Anchored to Stake.
Roller

Fig. 1

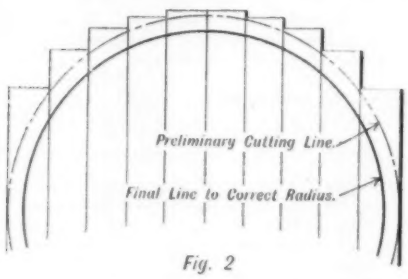


Fig. 2

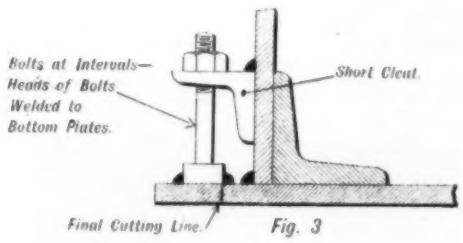


Fig. 3

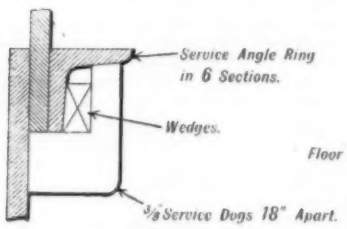


Fig. 4

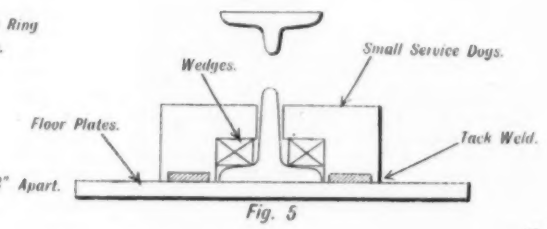


Fig. 5

South African Engineering Notes.

The New Platinum Process.

A DESCRIPTION of the new method of treating the platinum concentrates produced by the flotation process from sulphuric norite ores, which has been discovered by the metallurgical and laboratory staffs of the Central Mining and Rand Mines group, can now be given. The pyritic concentrate produced from the platinum ore by the flotation process is dried, and then roasted for approximately six hours at a dull red heat to eliminate sulphur and oxidise thoroughly all the base metals. After withdrawal from the roasting furnace the concentrate is mixed with salt, and is then placed in a chlorination furnace, where it is maintained at a temperature of between 500 deg. and 600 deg. Cent. for about five hours. During this period chlorine gas is passed over the furnace of the heated material, which is not disturbed in any way during the treatment. The chlorination converts the platinum group metals, also the copper and nickel present, into salts which are readily soluble in acidified water. Immediately after the withdrawal of the material from the chlorination furnace it is dropped into acidified water, and the solution of the metals is washed from the insoluble residue of gangue. The solution containing the platinum metals, together with the nickel and copper, is then agitated with powdered limestone, which precipitates the copper in the form of a green carbonate. The precipitate, which contains only a minute quantity of platinum, is then removed by filtration. The copper and platinum metals present in this precipitate may readily be recovered by smelting and electrolysis. The platinum metals are then precipitated from the solution as a black powder by agitation with zinc dust, and this powder is then ready for refining. The residual solution, after the removal of the precious metals, may be given a simple chemical treatment to recover its nickel content in a marketable form.

The insoluble gangue remaining after the chlorination treatment and washing, as described above, is cyanided in the usual manner to recover its gold content. The exact percentage of recovery has not been communicated, but it is given semi-officially as about 75 per cent. of the platinoid content of the original ore, a result which, it is believed, can be improved upon. The product can be shipped to refineries in Great Britain, and is of a kind that can readily be treated in those refineries to obtain refined metals in marketable form.

The proved features of the new process are that there is copper in handy form, there is nickel in finished form, for disposal, gold is obtained in finished form, and platinum metals are all ready to be sent to the refinery. In a simple way, without smelting, useful metals are separated from the ore. The process is less expensive from the platinum production point of view because of the revenue obtained from the other metals. Far-reaching results are expected in the development of the platinum industry as a result of this new method.

The questions now are :—(*a*) What is the world's consumption of platinum ; (*b*) how much may be sold without breaking the price ; (*c*) and what drop in price may the industry face without making the new method uneconomical.

Important Tin Development.

The Cuyser tin smelter, which was described in THE ENGINEER a while back, will be put to active test very shortly. A trial plant has been erected on the Rand, and operations will be started, under expert supervision, on some Transvaal tin concentrates. To exploit this invention, a company has been formed in Johannesburg.

Mineral Output.

The total value of the mineral production of the Union of South Africa, up to August 31st, was £32,824,860. The value of the diamonds produced is not included as for some reason—probably in connection with the control of output—the Government does not now publish the figures. It is understood, however, that production has fallen to the extent of about £1,000,000, and if that is approximately correct, then the value of the diamonds produced in the first eight months of 1928 will be about £7,000,000. The value of gold produced up to August 31st was £29,191,212 ; silver, £83,210 ; osmiridium, £59,247 ; platinum, £174,226 ; coal, £2,434,006 ; copper, £395,121 ; tin, £166,068 ; other minerals, £321,777. Among "other minerals" asbestos leads with an output valued at about £250,000 ; chrome ore follows with £23,000 ; and soda is next with £20,000.

New Rhodesian Railway.

The Mashonaland Railway Company, Ltd., has awarded to Pauling and Co., Ltd., of Westminster, the contract for the building of a branch line of 22 miles from Ndola to the Roan Antelope copper mines. The line will be independent of the line to N'Kana and N'Changa. The Roan Railway is now well in hand, and the ground has been cleared for about half the distance.

New Motor Factory.

General Motors (S.A.), Ltd., has signed a contract for the purchase of 40 acres of land at Port Elizabeth upon which it will erect a new factory which will be ready by the end of 1929. The cost of the factory will, it is said, be £250,000. The decision shows that this corporation has entire faith in the possibilities of the town and the capacity of the country to absorb production. At its present works there, the corporation is producing

about 100 cars per day, and employs a staff of about 800 people, while the pay roll is £16,600 per month. The chassis of the various American makes that the Corporation uses, are, of course, imported from the United States of America; but everything else is done at the factory, which is equipped for the manufacture of many of the parts required. Since it began operations in this country in 1926, the Corporation has invested over £2,000,000 here.

Benguella Railway Extension.

On October 20th a party of Belgian engineers, platelayers, &c., arrived at Cape Town from Europe, and went on by train at once to the Belgian Congo. They have come out to construct the Belgian portion of the Benguella Railway from the Congo border, to Angola, to link up with the line from the south at Tschilongo at a point about 125 miles from Bukama, the Belgian section of the line being 338 miles long. The Benguella line was this year opened to the old border line of the Congo, a distance of 772 miles from Lobito Bay. As a result of recent negotiations between the Belgian and Portuguese Governments, the south-east corner of the Congo, known as the Dilolo Boot, has been ceded to Angola in exchange for certain land in the north. The Congo border is thus moved eastwards, and the Benguella Railway in Angola will therefore extend a further 62 miles, and this section is now under construction.

The junction between the line to the Angola border and Tschilongo is expected to be made about 1930. The Benguella Railway is destined, in addition, to become part of a great Trans-continental goods and passenger route, also to have a far-reaching effect on the relationship of Katanga with its European markets. This is easily appreciated by comparing the distances from London to Elizabethville, the commercial centre of Katanga, which *viâ* Cape Town is 8488 miles, *viâ* Beira 9398 miles, but *viâ* the Benguella Railway and Lobito Bay only 6350 miles. The railway is built to the standard gauge of South Africa, namely, 3ft. 6in. The construction of the line presented many engineering difficulties, the climb to the Central plateau, which has an elevation of about 6000ft., covering 239 miles. Nevertheless, except for a very short section of rack, the ruling gradient of 1 in 40 has not been exceeded to Cubal (km. 197), while from Cubal to Huambo (km. 426) the ruling gradient is improved to 1 in 50, and beyond to 1 in 80. The locomotives of the Benguella Railway total 45. The system's latest acquisition is a number of exceptionally large "Garratt" locomotives, which were purchased from Beyer, Peacock and Co., Ltd. These locomotives have a maximum axle load of only 12·75 tons, but they develop a tractive effort of 46,200 lb. at 75 per cent. boiler pressure. They are giving excellent results hauling loads of 500 tons, compared with 230 tons, the load of the previous largest engine, known as the "Ninth" class.

New Port for the Belgian Congo.

It is believed among commercial circles in the Belgian Congo, that Banana, at the Congo mouth, is destined to become the great port of the future for the colony. The recommendation to make Banana the principal port of the country is said to have emanated from his Majesty King Albert during his recent visit. Banana has much deeper water and would, of course, make a more suitable harbour than Matadi. The largest of ocean-going steamers could anchor in safety at Banana, and it is quite possible that in the fairly near future this work will be taken in hand.

Rhodesian Railway Progress.

A bulletin issued by the General Manager for the Rhodesian Railways records very satisfactory progress during the first nine months of 1928. The total earnings were £3,775,831, an increase of £137,605 on the corresponding period of 1927. The gross expenditure was £2,255,066, an increase of £271,482, and the net operating revenue was £1,520,765, an increase of £133,897. Passengers carried amounted to 623,816, an increase of 158,020. The total passenger revenue was £216,235, an increase of £20,706. Both the rates for goods and for passenger traffic were considerably reduced as from May 1st, 1928. The tonnage of coal and coke carried was 656,235 tons, compared with 550,287 tons. The increase is mainly due to the larger requirements of the Union Minière of coal and its larger export of copper. There was a decrease of nearly 50,000 tons in chrome ore carried, but asbestos at 29,316 tons showed an increase of 5090 tons, and copper for export was 73,734 tons, an increase of 23,187 tons. Lead increased by 179 tons.

The option which the Rhodesian Railways had over the Rhodesian Katanga Junction Railway, extending from Broken Hill to the Congo border, a distance of 132 miles, which was constructed by the Rhodesian Katanga Junction and Mineral Company, Ltd., has now been exercised, and that line has become an integral part of the Rhodesian Railways system as from October 1st.

A considerable number of new locomotives and new rolling stock has been placed in service, and more are on order. A recommendation has gone to the Railway Board for the purchase of eight "Garratt" locomotives, and two articulated locomotives of a special type. Considerable additions were recently made to the locomotive workshops at Bulawayo, but they were not sufficient to meet the growing needs. Not only is new stock going into service continually, but fresh orders are being placed, so large extensions are to be made at the Bulawayo and Umtali shops. The programme at Bulawayo involves an expenditure of £50,000. It includes the purchase of a good deal of additional plant and machinery. At Umtali a comprehensive remodelling scheme is to be commenced during the coming year, and will probably extend over two or three years. New erecting boiler and machine shops are to be provided, and a considerable amount of additional plant and machinery will be required. The programme for the renewal of the permanent way provides for the re-railing of 62 miles in the Salisbury–Kalomo section and 40 miles of the Broken Hill–Congo Border section. A branch line is being constructed from a point near N'Dola Station to serve the Roan Antelope Mine, and another is contemplated to serve the N'Kana Mine, which will also connect with the main line near N'Dola.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

"Mopping-up."

In Midland and Staffordshire works this week efforts have been chiefly devoted to clearing everything up in readiness for the Christmas break, and for the stock-taking which takes place over the holiday at many of the local establishments. On the iron and steel market there has been little activity. New contracts were not to be expected so late in the year, and the falling off in purchases of raw material for current consumption has also been accentuated. Producers of iron and steel do not now anticipate any marked increase in orders until about the middle of January. For the most part they have no great bulk of business to carry over to 1929, but they are optimistic as to the likelihood of some reinvigoration of demand early in the New Year. Many of the manufacturing industries of the district give promise of better times ahead, and large quantities of iron and steel will be required for working up. The majority of the works are to have a full week's holiday, and only in establishments where pressure for deliveries exists, as in some sections of the heavy electrical and motor engineering branches, will work be resumed this year.

Pig Iron.

In the raw iron department of the market the battle for possession of the transport relief continues unabated. Coke suppliers are demanding for new contracts an advance equal to the amount of the rebate. Pig iron consumers are holding off the market for lower prices. No headway towards agreement appears to have been made during the past week, and transactions, in the absence of harmony, consist almost entirely of very small purchases of material necessary to enable works to carry on and of fuel purchases on the open market by blast-furnacemen to tide them over. Midland furnacemen are offering a strong resistance to the influences which have been impairing the market of late. Especially is this so with the Derbyshire furnacemen, who stand to gain much less than those of Northamptonshire on the transport relief. Consumers this week clung tenaciously to the concessions granted by some smelters last week and pressed strongly for more. Market negotiations, however, gave no sign of further yielding on the part of furnacemen. Indeed, on Birmingham Exchange to-day a number of Derbyshire houses were quoting £3 at furnaces for No. 3 foundry. Acceptance of a shilling less was qualified by circumstances. Northamptonshire makers were hardly so firm in their attitude towards quotations which ranged from £2 15s. to £2 16s. North Staffordshire producers asked £3 for the small amount available of this foundry material. East Coast hematite has been selling rather better here at £3 10s. to £3 11s. Forge materials are almost uncalled for, and quotations are purely nominal. Smelters this week derive some comfort and encouragement from the fact that the exports of foundry iron increased from 19,293 tons in October to 22,905 tons in November.

Finished Iron.

There is but a poor demand for finished iron, and works will be glad of the Christmas idleness, which they trust will enable them to strengthen their position somewhat by reason of additional orders coming to hand while the plant is standing. Marked bars sell at £12 per ton, and in this department there is a fairly steady demand, though it is much below output capabilities. The position is far from satisfactory in the Crown bar branch, makers having to face severe competition from firms nearer the coast. Staffordshire makers quote £9 10s. to £10, but Derbyshire, Lancashire and other outside makers' prices are considerably less. Crown bars can, indeed, be procured at as low as £9 per ton. The revival of work at the shipyards has brought encouragement to the makers of chain and anchor iron, who hope that the increased activity will benefit their trade at a later stage. Nut and bolt iron at £8 12s. 6d. finds few purchasers. There is consolation, even if it is selfish, in the fact that there is no great bulk of business going to the Continent. On 'Change in Birmingham to-day—Thursday—Birmingham merchants handling steel bars reported their inability to get specifications, a sure sign that the nut and bolt makers in the Black Country are badly off for work. They state that works in the Darlaston area are only active about three days a week. Wrought iron gas tube strip sells steadily at £10 15s. upwards.

Steel.

There has been no development of note this week in the steel department. Engineers have no difficulty in obtaining prompt delivery of English steel of every description at recent rates. Rolling lists indicate a wide variety of orders to be executed, although the tonnage is nothing like sufficient to maintain continuous operations at the mills. The Steel Association maintains the price of joists at £7 17s. 6d., and plates at £8 12s. 6d. Ship, bridge and tank plates, ¾in. and over, are £8 12s. 6d. Staffordshire steel hoops are quoted £10. Both English and Welsh billets are procurable at £6 5s., while users pay round about £7 15s. for small rolled bars. Continental material is not being pressed upon the market, and little business is passing either to home or foreign producers. Foreign bars and joists could be had on somewhat lower terms if the business were available. There has been an advance of prices, amounting to about 2s. 6d., in the wire branch. It can hardly be said, however, that this was unexpected, for Germany has held so large a share of the wire trade that some stringency in that department as the result of the lock-out was practically anticipated. Birmingham engineers have been offered this week joists from the Charleroi district at £5 2s. f.o.b. and steel bars at £7 5s. delivered. No. 3 Belgian iron is quoted at £7 2s. 6d. delivered. This can be obtained in a matter of six to ten weeks. Continental billets can be had at £5 18s.

Sheet Prices.

The deficiencies in galvanised sheet producers' rolling programmes, to which I referred last week, and which accounted for some price shading, appear to have been filled up, and prices have again taken on a firm, if not higher, tone. The temporary shading of quotations for big-scale business had the effect of quickly bringing considerable overseas orders for January, and bookings are now proceeding for February and March. Galvanised corrugated sheets of 24 gauge are quoted £13 10s. as a minimum, and quite a number of mills ask as much as £13 15s. There is no change in the other departments of the sheet trade.

Cast Iron Pipes.

Producers of cast iron pipes in this area are exceptionally well employed at date. Indeed, this would appear to be the most active section of the trade just now, and there is every indication that its prosperity will continue for some time to come. Production of cast iron pipes is largely carried out by one firm in Derbyshire, and this concern has its four blast-furnaces all at work.

Moderate Trade Improvement.

It is encouraging to Midland industrialists generally to find that last month British exports again made some slight recovery. To have not only maintained October's recovery, but to have added to it is a feat which should incite manufacturers to look ahead with confidence. Iron and steel masters were interested to discover that the total quantity of iron and steel imported during November was less by 28,637 tons than in the previous month, and 51,997 tons lower than the imports for the corresponding month last year. For the year to date the quantity imported stands at 2,712,259 tons, compared with 4,125,605 tons for the eleven months last year. This gives much cause for satisfaction.

Production.

Midland iron and steel masters were agreeably surprised to learn that there had been a further slight improvement in the production of iron and steel during the past month. True, the increased tonnage was not very large, but such as it was it was welcome, as showing progress rather than retrogression. It is noted that although the number of active blast-furnaces declined by one to 135, the production of pig iron in November amounted to 544,400 tons compared with 543,600 tons in October and 575,900 tons in November, 1927. The daily rate of output was 18,147 tons in November, compared with 17,536 tons in the preceding month. Of the production, 171,700 tons were hematite, 216,700 tons basic, 112,200 tons foundry, and 17,100 tons forge pig iron. Production of steel ingots and castings during the month amounted to 762,500 tons, compared with 756,000 tons in October and 698,700 tons in November, 1927.

Magnesium Alloy Castings.

On the 13th inst., Mr. E. Player, of Coventry, read at a meeting in Birmingham of the Co-ordinating Committee representing the Staffordshire Iron and Steel Institute, the Birmingham Metallurgical Society, and the Birmingham Local Section of the Institute of Metals, a paper on "The Production and Properties of Magnesium Alloy Castings." Mr. Player described the practical processes involved in the manufacture of magnesium alloy castings. He said that the impression that such alloys were yet in the experimental stage was an erroneous one. Production was now on a strictly commercial scale of quantity, techical excellence and cost, thus offering the engineer a new material possessing many desirable qualities. Magnesium formed alloys with zinc, aluminium and copper, which had excellent casting qualities and physical properties. Copper did not form a principal constituent of any of the "electron" alloys, because copper formed alloys that were very subject to corrosion under certain conditions. All the magnesium alloys, he added, possessed excellent machining qualities, comparing favourably with aluminium alloys in that respect.

Mobile Fuel Tanks.

As the result of trials with a new kind of mobile fuel tank during the recent R.A.F. Pageant and the Army Manœuvres, a big Government contract has been placed with Thompson Brothers, Ltd., Bradley Works, Bilston. The tanks are of 350-gallon capacity, and embody new pump gear which automatically measures the required amount of fuel to be delivered. The contract is for thirty-eight tanks, twenty-four being for the India Office to be mounted on R.A.F. trailers, and fourteen for the R.A.F., mounted on Morris six-wheeled chassis. The tanks are of an improved type to those recently experimented with, and include, in addition to a special type of flow meter, which ensures accuracy of measurement no matter at what angle the vehicle may be standing, a safety device for preventing explosions and a safety pressure valve. The tanks are welded by a special electric process employed by the firm, and represent two years' development work.

Rolling Stock.

Midland rolling stock establishments continue to secure a share of the orders coming from the Dominions, and it is announced that the Metropolitan Carriage, Wagon and Finance Company, of Birmingham, has just secured a contract for thirty second-class railway saloons for South Africa, costing £3200 each.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

A Problem for Power Producers.

If the Court of Appeal majority decision delivered last week is not itself reversed power generating undertakings will be confronted with a difficult and, probably,

extremely costly problem. The appeal in question was that of a farmer from a decision given by Mr. Justice Talbot at the Manchester Assizes earlier in the year in favour of the Manchester Corporation. The Corporation was the defendant in an action for an injunction to restrain it from emitting sulphur-laden fumes from the Barton Power Station to the damage of the plaintiff's property. The alleged nuisance was not denied by the Corporation, which, however, relied for the defence upon the plea that as the power station was of a kind authorised by Parliament at the place in question, and as the nuisance could not be avoided, it was not liable. This also was the view taken by Mr. Justice Talbot, but it has now been reversed by the majority decision of the Court of Appeal, the plaintiff being awarded damages with costs in both Courts. The operation of the injunction which was granted was suspended for a year to enable the Corporation "to adopt such measures as it is advised to stop or mitigate the nuisance, with liberty to apply after a year for suspension or variation of the injunction." The opinion of Lord Scrutton in the Court of Appeal was that the special Act of 1914 did not vary the operation of the nuisance clause in the general Act of Parliament. At the time of writing it is not known whether or not the Electricity Committee will take the matter to the House of Lords. Obviously, in view of the fact that the Barton Station is generally acknowledged to be one of the most efficient in the country, and that large sums of money have already been expended in endeavouring to solve the problem, the decision is one of tremendous importance and will not be confined in its effects to Manchester alone.

A Central Electricity Board Appointment.

Mr. R. Blackmore, chief engineer of the Stalybridge, Hyde, Mossley and Dukinfield Tramways and Electricity Joint Board, has been appointed by the Central Electricity Board as engineer for the North-West England and North Wales area. Mr. Blackmore has been with the Joint Board since it was established in 1904, and has acted during recent years as consulting engineer to the Accrington, Fleetwood, Leigh, Nelson, Oldham, and Glossop Corporations. For the time being, until arrangements have been made for offices in or near Manchester, Mr. Blackmore's temporary offices will be at the generating station of the Joint Board at Tame Valley, Stalybridge.

Increasing Capital.

Shareholders' sanction to a substantial increase in capital is being sought by the directors of the Lancashire Electric Power Supply Company. The company is one of the largest electricity undertakings in the country, and has a power plant rated at 91,800 H.P. at Radcliffe, and another of 40,900 H.P. at Padiham, while a third of 83,000 H.P. is in course of construction at Kearsley, and is expected to be generating current in about twelve months. All three are selected stations under the Central Electricity Board's North-Western scheme. The company's sales have grown from 5,380,000 units in 1907 to 175,000,000 units last year, current being supplied to the greater part of industrial Lancashire.

University Appointments.

Manchester University Council has appointed Mr. R. M. Anderson, Lecturer in Mechanical Engineering, a member of the Board of Faculty of Technology, and Mr. J. W. Cuthbertson has been appointed Assistant Lecturer in Metallurgy.

Non-Ferrous Metals.

Price movements among the non-ferrous metals have been less sensational during the past week so far as tin is concerned, although not without interest in most sections. After the slight relapse recorded a week ago copper has again been in the ascendant and standard brands of the metal have touched new high levels. Signs have not been wanting of easier buying conditions in respect of most of the metals, and copper has not been an exception, although a fair business in standard has been done during the past week, and also in manufactured copper. The tin section is obviously in a nervous and unsettled condition, and this has been reflected in the demand. The market has been conspicuous by ups and downs during the period under review, but at the moment of writing values seem to have settled about midway between the highest and the lowest points touched, and on balance are £2 10s. to £3 per ton below the level reported a week ago. There has been no more than a moderate demand about for spelter, but there has been a continuation of the steady upward movement of prices, though to a much less marked degree than in either of the two previous weeks, the market inspiration in this case being derived from the reported formation of an international cartel among producers of the metal. Buying interest in the case of lead has been comparatively limited, but there has been no alteration in prices on balance, offers being maintained at the lower level touched a week ago.

Iron and Steel.

Dull and uninteresting conditions have characterised the iron and steel markets during the greater part of the week. Local foundries have been specifying for moderate quantities of iron against contracts, but in neither this respect nor from the point of view of new orders have they been keen operators, and from now on until after the holidays market business will be virtually at a standstill. So far as prices are concerned, these are at 67s. 6d. to 68s. per ton for Derbyshire No. 3; 67s. to 67s. 6d. for Staffordshire; 79s. for Middlesbrough; 87s. 6d. to 90s. for Scotch, and about 82s. for hematite. The steel market is inactive, although in the early part of the week rather more buying than of late was reported in the constructional engineering branch. This, however, was in the nature of a temporary spurt. One or two moderate-sized parcels of boiler-plates have also been disposed of, and some moderate buying has been going on in the case of small bars. As before, however, rollers of plates, generally, are finding conditions unsatisfactory. There has been no change in the price position, quotations keeping fairly firm at recent rates. The tendency in the market for continental iron and steel materials is undoubtedly easy, although there has been no further actual change. Several inquiries for fair quantities have been reported within the last few days, but there has been no evidence of much buying going on.

BARROW-IN-FURNESS.

Hematite.

There is an improvement in the general tone in the hematite pig iron market in the North-West district. The hand-to-mouth habit which most customers had developed during the quiet period is changing, and there is a decided tendency on the part of many buyers to place orders for forward delivery. This is in itself a sign that the future is more secure, and that the requirements of customers are on the upgrade. The fact that the steel departments at Barrow, which have been idle for the past three weeks, have restarted this week means a much greater local demand for iron. All the makers are clearing their output, and there is a fairly good proportion of special quality iron in demand. The trade with the Continent is not heavy, but recently there have been several shipments of small cargoes. America has also been buying, and there have been dispatches from Barrow to Philadelphia. The iron ore trade is about the same as far as local demands are concerned, but there is a better prospect for trade outside in view of the general improvement in the iron trade. Foreign ore is not being imported in large tonnage at present. The steel trade is slightly better, and Barrow has restarted its rail mill this week. The merchant mills had started previously. Barrow will work over Christmas, a thing which has not occurred for many years. Over seven thousand tons of rails were shipped at Workington for South America and Egypt. The hoop mills at Barrow are well employed.

SHEFFIELD.

(From our own Correspondent.)

The Approach of Christmas.

WITH the holiday season and the stocktaking period drawing near, there has been a falling off in the placing of new business, but this is probably due, in the main, to end-of-the-year influences and not to any actual decline in trade. The caution which is being displayed by consumers of iron and steel would seem to indicate a lack of confidence in the future, but, on the other hand, there is certainly a fair amount of optimism about, owing to the improved outlook in the number of centres of the metal trades. A reduction in the output of soft steels is considered a mere seasonal fluctuation, as the sales in this department continue large, and there is a good promise of continued work. The increased activity reported in shipbuilding and engineering is sure to be of benefit to Sheffield by bringing a larger demand for steel and tools.

Railway Orders and Prospects.

The railway steel departments have had a very thin time this year, the orders from home companies having been especially on the small side. It is considered certain, however, that next year will see an improvement on this side. There has already been a substantial increase in the demand from overseas railways, and an excellent order is reported this week. The South African Railways Administration has placed a contract with the Leeds Forge Company, Ltd., for 600 steel high-sided bogie wagons each of 80,000 lb. capacity. The value of the order is £225,000. The Leeds Forge Company is a subsidiary of the Sheffield firm of Cammell Laird and Co., and although the actual building of the wagons will be carried out at Leeds, the axles and springs will be made at Cammell's Sheffield works, and the tires by the same firm at Penistone. Messrs. Cammell's present staff will be able to deal with the work, and there is no likelihood of further men being engaged. The order follows one for 400 wagons of similar type, which has just been completed by the same firm. It is a welcome evidence of the increasing preference for British goods over the lower-priced but less reliable foreign products. Generally speaking, a better year in the export trade is expected. This country has lost a good deal of ground in its trade with India, but a recovery is now in progress. Business with the Far East has been at a low ebb for some time, and increased purchases from China are probable, while there is also a strong belief that something will be done before long to restore commercial relations with Russia. The restoration of the trading power of those two great countries would do a great deal towards bringing about a renewal of full prosperity in British industry.

Vickers-Cammell Merger.

The details are now available of the important amalgamation of interests between the Vickers and Cammell firms, with which rumour has been busy for the past two or three months. It is on a large scale, and promises to present a fine example of the value of co-ordination and rationalisation. Details of the amalgamation appear elsewhere in this issue. The chairmen of both the principal companies concerned have been asked what the new agreement will mean with regard to the closing of works in Sheffield and consequent unemployment. General Sir Herbert Lawrence, speaking for Vickers-Armstrongs, replied that there need be no fear of anything like that happening. The agreement was made, he said, to obtain better and more efficient working arrangements, with a resulting benefit all round. Mr. W. L. Hichens, chairman of Cammells, said that as the whole object of the agreement was to effect economies in working, there was little doubt that a certain number of employees would be dismissed, and those parts of the works that were old and run at a loss would doubtlessly be closed down. He added that the details of any such changes had not been discussed, and the whole question would be gone into very thoroughly before any action was taken.

At Staveley Works.

Increased activity is reported at the Devonshire Works, Staveley, of the Staveley Coal and Iron Company, Ltd. No. 2 blast-furnace has been relit after being out of commission for about a month, owing to a mishap, and all four of the blast-furnaces are now in full blast for the first time since January last. Contracts for cast iron pipes recently received by the company include the following:—7500 tons, 27in., 30in. and 33in., for Bristol Waterworks; 3575 tons, 3in. to 14in., for Messrs. William Wilson; 1000 tons, 4in., 6in., and 12in., concrete lined, for Birmingham Corporation; and 1250 tons, 4in. to 12in., for Glasgow Corporation. The plant for the lining of cast iron pipes with concrete, recently installed at the works, has now commenced operating.

An Offer for a Fleet.

The shipbreaking industry in this country, which is rather slack at present, will receive a welcome stimulus if an offer made by Thos. W. Ward, Ltd., of Sheffield, to the United States Shipping Board is accepted. The offer is for a fleet of forty-five ships, which were built during the war for use as cargo boats, each having a carrying capacity of 5000 tons. The amount of Messrs. Ward's bid is £155,000. There are said to be eight offers altogether, one of which, from the Union Shipbuilding Company, of Baltimore, amounts to £84,700, while another, from the Boston Iron and Metal Company, is £137,000. Two or three German firms have submitted offers.

Hull's Great Scheme.

An enormous amount of work of an engineering character will be required at Hull during the next few years if the many development schemes now on foot materialise. Progress is to be reported this week in connection with two of those projects. The City Council has approved of the abolition of the level crossings, subject to a conditional offer of £560,000 by the Unemployment Grants Committee in fifteen annual instalments being obtained. There are ten level crossings in the city and five of them bisect main traffic arteries. It is proposed to replace the crossings by steel viaducts with overhead railways. The estimated cost of the constructions, which will provide work for nearly 2000 men for five years, is £1,117,000, towards which the L.N.E.R. Company has offered to contribute £100,000. The town Planning Committee of the Corporation has been discussing the construction of a proposed new street from Paragon-square to the junction of Beverley-road and Spring-bank. Already £300,000 has been spent in acquiring property which will have to be demolished. Mr. F. Bricknall, the late City Engineer, recommended that the new street should be 120ft. wide, which would allow for six tracks in the carriageway and a 20ft. footpath. The Committee agreed to recommend a width of 110ft., and that all buildings erected in the street should have a minimum height of 50ft. to the eaves. It was also proposed that parliamentary power should be sought for the borrowing of £100,000 for the erection of buildings in the new street, but this matter was left in abeyance in order to obtain an opinion from the Acting Town Clerk as to whether such power was likely to be granted to other cities.

Artificial Silk Factory at Doncaster.

The scheme for the establishment of an artificial silk factory on the outskirts of Doncaster by the British Bemberg Company, Ltd., is also making progress. Doncaster Town Council has approved of the scheme, and has decided to sell to the company, subject to the consent of the Ministry of Health, 7 acres of land for £1400. It has also authorised several agreements, including one with the L.N.E.R. and the British Bemberg Company, for the construction, maintenance and working of a railway line from the Marshgate sidings to the site of the factory, and the erection and maintenance of a bridge over the canal of the South Yorkshire Navigation Company. It is expected that the factory will provide employment for 1500 to 2000 people.

Sheffield's Lighter Trades.

There is little of a cheerful character to report about the cutlery and electro-plate trades of Sheffield. The seasonal trade is practically over, and the general opinion is that it has been the poorest for years. Very little cutlery is being bought over the ordinary retail counter. A good deal of work is still being provided by large special contracts, and there is a well-sustained demand for cases and cabinets of cutlery. An opinion is growing that the demand for stainless knives has almost been satisfied, at any rate for a time, as vast quantities have been sold and they last much longer than those made of ordinary steel. On the other hand, many of those distributed have been of inferior quality, and it is hoped that people will find it necessary to replace them with knives of a better standard.

NORTH OF ENGLAND.

(From our own Correspondent.)

New Works for the Tees?

THERE is a prospect of a further utilisation of reclaimed sites on the north bank of the Tees, between Billingham and Seaton Snook, at a fairly early date. Firms are understood to be in negotiation with the Tees Conservancy Commission for the acquirement of some of this land for industrial purposes. Discussions are not yet at that stage when it is possible to state what the proposed development involves. It may, of course, not come to anything, but should it proceed at all, it is safe to say that further variety will be introduced into the industries of Tees-side—monopolised for so long by iron and steel—and that eventually, on the 300 acres or so involved in the negotiations, work will be found for a considerable number of men. The enterprise of the Tees Conservancy Commission in reclaiming the waste marshes on both banks of the river is thus likely to receive further justification. The Commission is about to embark on a £500,000 deepening, widening and reclaiming scheme, and Sir Hugh Bell,

Bart., its chairman, said a few days ago that it may have to spend £1,000,000 to meet the changing complexion of the port.

New Tees Crossing.

A definite step forward in providing a further link between North Yorkshire and South Durham was taken at a conference of representatives of local authorities and industrial interests, when a bridge was decided upon in preference to a tunnel for the proposed new crossing over the river Tees at Newport. The bridge, which will be of the lift type with a span of 250ft., is estimated to cost £470,000.

Cleveland Iron Trade.

Curtailment of market operations owing to the approach of the Christmas holidays has had no weakening influence on quotations, and considerable activity is promised when matters settle down in the New Year. Most of the output of Cleveland pig iron is still conveyed direct in a molten state to producers' own consuming works, and the surplus that is run into the pig beds is reported to be fairly well disposed of, though keen competition for orders by iron manufacturers in other home districts continues in certain markets. Cleveland makers adhere firmly to recent quotations, No. 1 foundry being 68s. 6d. ; No. 3 G.M.B., 66s. ; No. 4 foundry, 65s. ; and No. 4 forge, 64s. 6d.

Hematite Pig Iron.

In the East Coast hematite pig iron trade some uneasiness is felt at the threatened inadequate supply. Makers' stocks have vanished, and current production is absorbed as it is turned out. The situation will, however, be relieved early in January by the rekindling of furnaces at the Ayresome Ironworks of Gjers, Mills and Co., Ltd., where extensive alterations and improvements have been made. Orders for hematite are not easily placed at below the equivalent of 71s. for ordinary qualities, and some makers report contracts arranged on higher terms.

Ironmaking Materials.

Sales of foreign ore continue few and small, but merchants confidently anticipate an upward movement in values. The minimum c.i.f. Tees figure for best Rubio ore is 22s. 6d. Demand for blast-furnace coke is slightly better, but local consumers are still disinclined to negotiate for large quantities. Good average qualities are firm at 17s. 6d. delivered to works in this area.

Manufactured Iron and Steel.

Conditions in the manufactured iron and steel trade show a welcome change for the better. Substantial orders for railway material have been booked, and specifications for shipbuilding requisites promise to be fairly freely distributed in the very near future, while inquiries for constructional engineering steel are circulating, and producers of all kinds of sheets have contracts that will keep them busy for several months. Prices are firmly maintained.

The Coal Trade.

The week preceding Christmas is usually quiet on the Northern coal market, as shippers have very largely covered their arrangements, and loading turns are correspondingly full. There are not, therefore, many opportunities for placing fresh business. Right up to Christmas Eve the collieries in both Northumberland and Durham are favourably placed, and shipments are likely to be on a large scale. There is every sign that the New Year will open on a firm note, but neither producers nor buyers are operating far ahead. The general demand has promise of being well sustained. Steams are in best request, so far as large varieties are concerned, and smalls are selling rather more freely, which is a welcome fact to collieries with brisk trade in other respects. Despite recent depressed conditions there are pits in Northumberland which have not lost a day this year. There is little large steam coal available for early delivery, and prices are firmly maintained. Best Northumberland steams are quoted at 14s. to 14s. 3d., and seconds at 13s. 3d. to 13s. 6d. Steam smalls are in better request, and gas fuel is up to average seasonal requirements. There is more trade for coking coals at recent figures, and bunkers are selling well, particularly the superior brands. There is a good general demand for patent cokes, and supplies for three or four weeks ahead are scarce and firmly held at 18s. 3d. to 19s. Beehive cokes and special foundry grades are firm at 23s. 6d. to 28s. 6d. Gas coke is in slow demand and plentiful at about 18s. 6d.

Cleveland Miners' Wages.

The Cleveland ironstone miners have decided to request the employers to fix a subsistence wage as an absolute minimum for all men engaged in or about the mines and quarries.

SCOTLAND.

(From our own Correspondent.)

Steel and Iron.

WHILE business in steel and iron continues more or less on recent lines, there is a more hopeful feeling in the market with regard to the future, when the effect of reduced railway charges and the benefit derived from the derating proposals, which will be brought into operation some time next year will become apparent. In the meantime, there is some improvement in heavy steel. Some works producing this material are now comparatively busy, and there are prospects of further improvement if certain shipbuilding orders which are pending are definitely fixed up. Despite this being the dull season makers of light steel sheets report a fair turnover. Galvanised descriptions also are comparatively well off for orders. The bar iron market still shows little movement. For a considerable time past makers have had difficulty in maintaining even a moderate turnover, and there is no sign of a change for the better. Prices are nominally unchanged, but there is little doubt that a good export order could be done somewhat under £9 15s. per ton. The demand for re-rolled steel is comparatively good, though not so prolific as during the month of November, when business was affected by the trouble in the Ruhr. The quotation remains firm at £7 15s. per ton, home or export. The demand for scrap is very moderate, with heavy steel and cast iron unchanged at 65s. and 62s. 6d. per ton respectively.

Pig Iron.

Only twenty furnaces are in blast in Scotland, but supplies are still more than ample to meet all demands. Prices quoted are unchanged, but are not always realised.

Exports and Imports.

About 14,000 tons of iron ore, 5600 tons of steel and iron, and 800 tons of plates were unloaded at Glasgow Harbour during the past week. Shipments of steel and iron amounted to 3800 tons and pig iron to 460 tons.

Labour Affairs.

Over 30,000 workers in Scotland will be affected by the proposed amalgamation of the Workers' Union and the Transport and General Workers' Union, regarding which ballots of the various branches are now being taken.

Coal.

In view of the holidays the coal market is somewhat more active. The collieries, as a rule, are well employed, exporters having been busy arranging for shipments contracted for some time ago. Practically all classes of fuel are in demand, and supplies, as a rule, short, and consequently the market is firm. Lanarkshire splints and ells are particularly strong, and best Fifeshire steams firm. In all districts washed nuts are comparatively well placed. Shipments amounted to 243,067 tons, against 247,300 tons in the preceding week, and 252,831 tons in the same week last year. So far as new business is concerned, the market is quiet, very little having been booked so far for January delivery. The home market has been busier lately, owing to colder weather conditions, and in some instances the collieries have obtained better prices.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

THERE has been no development in the conditions prevailing in the steam coal trade except that the feeling that business is drying up in view of the holidays has become more pronounced this week. This is only natural, as apart from the fact that the inquiry from abroad shows no material expansion, there is the difficulty of securing coals for prompt loading owing to the fairly heavy commitments of collieries. If all the tonnage came along as arranged, there is no doubt that most of the leading undertakings would not have any coal at all to spare for the next fortnight ; but the weather at sea has been very bad lately, and that has upset the movement of steamers, the consequence being that some collieries, which were fully sold according to book, have unfortunately not been able to ship as they expected, and have had to look round for a spot buyer. That, of course, has been the exception ; still there is no doubt that although arrivals of steamers over last week-end were fairly good, they were not up to expectations, as on Monday there were thirteen idle tipping appliances, and only about half-a-dozen steamers waiting to get into berth. Still, on the whole, it can be said that, compared with the conditions of a few weeks ago, collieries have been fairly busy, and a satisfactory feature is that, despite the fact that new business is not so brisk as to make exporters really feel that things are improving, nevertheless quite a good number of orders are held. Chartering operations continue to be active, and still the demand is well sustained, though tonnage is not freely offered. Altogether the feeling prevails that collieries should continue to be well engaged well into the New Year. No big contract inquiry is reported, though it is reported that the M. Z. A. Railway of Spain is asking for prices for about 25,000 tons of steam coal for delivery over the first three months of 1929.

Docks Facilities.

Towards the end of last week a deputation of Barry and Penarth tippers had an interview with Mr. C. S. Page, the chief docks manager of the Great Western Railway Company concerning the closing of tipping appliances at Cardiff and Barry. The men's leaders expressed the contention that there was no need for the withdrawal of the appliances. On the other hand, Mr. Page stated that there was no justification for the company altering its decision, though he added that, if trade improved and warranted it, the company would be pleased to bring the appliances again into operation. At the same time it was understood that if the men were prepared to accept the 2½ per cent. cut in wages it would mean the retention of 100 workmen. Penarth tippers and Barry tippers held meetings over last week-end to reconsider the position, but it is reported that they decided to adhere to their previous decision not to agree to cuts in their wages, so that the decision of the Great Western Railway Company to stop the working of three appliances at Cardiff and three at Barry remains in force.

Pitwood Importers and Period of Credit.

The decision referred to last week of the Cardiff and Bristol Channel Pitwood Importers' Association to restrict as from the beginning of the New Year the period of credit to seven days, or cash less ½ per cent. discount at sellers' option, has caused a good deal of resentment on the part of coalowners, who consider the decision to be not only unreasonable in view of the difficulties already being experienced by colliery undertakings, but extremely inopportune. The coalowners of this district as a body intend, it is reported, to make severe representations to the Pitwood Importers' Association, while individual undertakings are credited with the intention of resisting the importers' action to the very utmost.

Miners and Distress.

A feeling of satisfaction prevails in this district that a real effort is being made to relieve the distress which prevails in the coal mining valleys. The action of the Government and also of private individuals is welcomed, as the conditions in some areas are indeed serious. Despite all that is being done, it is to be feared that thousands will have a very depressing Christmas. In some areas fully a third of the population are unemployed. Apart from this fact reports are current that in some areas relief is being withheld from particular workmen on the ground that they are not trade unionists. Both the officials of the South Wales Miners' Federation and the Miners' Industrial Union stoutly deny that there is any foundation for this report. The allegation has resulted in special investigations being made, and hopes are held that it will be found to be without substance.

Miners' Wages.

Sir Francis Taylor, the independent chairman of the Coal Conciliation Board for South Wales, attended a special meeting of the Board at Cardiff on Tuesday to hear the arguments put forward by the coalowners for a decrease in the minimum rates and the subsistence allowances to be paid to the lower-paid workmen and those submitted by the workmen's representatives for an increase, details of which have already been given. Sir Francis Taylor will give his award shortly, but the impression prevails that he will dismiss both applications.

Regulation of Output.

The decision of coalowners and colliery undertakings, whether they are agreeable to accept the scheme for the regulation of coal output in conjunction with the existing arrangements for the maintenance of minimum prices, had to be given last Saturday. There was also a meeting of the Executive Committee of the South Wales Coal Marketing Association on Tuesday to consider the situation in view of the response. So far no information has been disclosed as to whether coalowners have accepted in sufficient numbers to make the scheme workable. It was stated when the scheme was issued that to make it effective favourable decisions were necessary from coalowners producing 85 per cent. of the total production. In some quarters it is reported that this has been obtained, but in other directions it is stated that this is not the case. The scheme is supposed to come into operation on January 1st.

LATER.

The introduction of the scheme for the regulation of coal production, which was intended to operate from January 1st, has been deferred. Several collieries have been unable, so far, to give their assent to the scheme, for the reason that they have not had sufficient time to consider the matter, and the Executive Committee of the South Wales Coal Marketing Association will therefore meet again in three weeks' time. In the meantime existing arrangements respecting voluntary observance of the minimum price scheme will continue.

Current Business.

The tone of the steam coal market for prompt shipment is quite firm for most descriptions. In some instances collieries are able to quote 3d. to 6d. above the minimum prices for any coals they can spare, but in other cases sellers find comparatively little inquiry, and are not so well placed owing to their tonnage not arriving to hand as expected. Still, on the whole, the market is good, and in view of the holidays, there is a likelihood that it will continue so for a week or two into January. Coke is steady, but patent fuel remains comparatively quiet. Pitwood is barely steady round about 27s. 6d. to 27s. 9d.

CONTRACTS.

THE LEEDS FORGE COMPANY, Ltd., of Leeds, has received from the South African Railway Administration an order for 600 steel drop-sided bogie wagons, each of 80,000 lb. capacity.

THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has received from the Bristol Corporation an order for a turbo-alternator set, together with extensions to the boiler plant, switchgear and transformer equipment. The new set will consist of a 51,250-kW turbine driving at 1500 revolutions per minute a main alternator of 62,500 kVA, and a house service alternator of 1560 kVA.

SIR W. G. ARMSTRONG, WHITWORTH AND CO., Ltd., Kinnaird House, Pall Mall East, London, S.W. 1, have received orders for Monometer plant and furnaces from Kromhout Motors, Holland ; Messrs. Werkspoor, Amsterdam ; Workman, Clark and Co., Ltd., Belfast ; John Kincaid and Co., Greenock ; Holmes and Co., Hull ; J. Jobling and Co.; Booth and Co., Birmingham ; Reavell and Co., Ltd., Ipswich ; the Liverpool *Journal of Commerce* ; Messrs. Felten and Guilleame ; the *Kölner-Zeitung* ; Lucas and Co.; and Deutsche Motors.

CATALOGUES.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, W.C. 2.—Particulars of the winding plant at the McIntyre Porcupine Mines, Canada.

BABCOCK AND WILCOX, Ltd., Babcock House, Farringdon-street, London, E.C. 4.—Particulars of the "Babcock" low-temperature coal distillation system.

UNDERFEED STOKER COMPANY, Ltd., Africa House, Kingsway, W.C. 2.—A brochure dealing in detail with the "Louvre" stoker, one of the firm's new products.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
(1) Native	17/- to 19/-
(1) Spanish	21/-
(1) N. African	21/-
N.E COAST—	
Native	18/- to 21/-
Foreign (c.i.f.)	22/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	3 14 0	—
No. 1 Foundry	3 15 0 to 3 16 0	—
No. 3 Foundry	3 11 0	—
N.E. COAST—		
Hematite Mixed Nos.	3 11 0	3 11 0
No. 1	3 12 0	3 12 0
Cleveland—		
No. 1	3 8 6	3 8 6
Silicious Iron	3 8 6	3 8 6
No. 3 G.M.B.	3 6 0	3 6 0
No. 4 Foundry	3 5 0	3 5 0
No. 4 Forge	3 4 6	3 4 6
Mottled	3 4 0	3 4 0
White	3 4 0	2 4 0
MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	—	—
North Staffs. Forge	—	—
,, ,, Foundry	3 2 6	—
(3) Northampton—		
Foundry No. 3	2 15 0 to 2 16 0	—
Forge	2 11 6 to 2 13 6	—
(3) Derbyshire—		
No. 3 Foundry	2 19 0 to 3 0 0	—
Forge	2 15 0 to 2 18 0	—
(3) Lincolnshire—		
No. 3 Foundry	3 0 6	—
No. 4 Forge	2 17 6	—
Basic	3 0 0	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 0 0 (a) / 4 2 6 (b) / 4 5 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. COAST—		
Iron Rivets	11 5 0	—
Common Bars	10 5 0	—
Best Bars	10 15 0	—
Double Best Bars	11 5 0	—
Treble Best Bars	11 15 0	—
LANCS.—		
Crown Bars	10 0 0	—
Second Quality Bars	9 10 0	—
Hoops	13 0 0	—
S. YORKS.—		
Crown Bars	10 10 0	—
Best Bars	11 0 0	—
Hoops	12 10 0	—
MIDLANDS—		
Crown Bars	9 0 0 to 10 0 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	8 12 6 to 8 17 6	—
Gas Tube Strip	10 15 0 to 10 17 6	—

STEEL. (d)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	10 10 0	10 10 0
Ship Plates, ¼in. and up	8 7 6	7 12 6
Sections	7 17 6	7 2 6
Steel Sheets, ¼in.	8 15 0	8 12 6
Sheets (Gal.Cor. 24 B.G)	13 10 0	13 12 6 to 13 15 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	8 7 6	—
Angles	7 17 6	—
Boiler Plates	12 15 0	—
Joists	7 17 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	7 12 6	—
Soft Billets	6 15 0	—
N.W COAST—		
BARROW—		
Heavy Rails	8 0 0	—
Light Rails	8 5 0 to 8 10 0	—
Billets	6 15 0 to 9 15 0	—
MANCHESTER—		
Bars (Round)	8 17 6	—
,, (Small Round)	8 0 0 to 8 2 6	—
Hoops (Baling)	10 0 0	9 15 0
,, (Soft Steel)	9 0 0	8 15 0
Plates	8 12 6 to 8 17 6	—
,, (Lance. Boiler)	9 10 0 to 9 15 0	—
SHEFFIELD—		
Siemens Acid Billets	9 0 0	—
Hard Basic	8 12 6	—
Intermediate Basic	8 17 6 and 7 12 6	—
Soft Basic	8 12 6	—
Hoops	9 0 0	—
Soft Wire Rods	7 12 6	—
MIDLANDS		
Small Rolled Bars	7 15 0 to 8 0 0	—
Billets and Sheet Bars	6 5 0 to 6 7 6	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	—
Galv. Sheets, f.o.b. L'pool	13 10 0 to 13 15 0	—
Angles	7 17 6	—
Joists	7 17 6	—
Tees	8 17 6	—
Bridge and Tank Plates	8 12 6	—
Boiler Plates	11 0 0	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	18/- to 18/1½
Block Tin (cash)	224 17 6
,, (three months)	223 17 6
Copper (cash)	68 16 3
,, (three months)	68 11 3
Spanish Lead (cash)	21 5 0
,, (three months)	21 13 9
Spelter (cash)	26 16 3
,, (three months)	26 12 6
MANCHESTER—	
Copper, Best Selected Ingots	74 2 6
,, Electrolytic	75 10 0
,, Strong Sheets	98 0 0
,, Tubes (Basis Price), lb.	0 1 1½
Brass Tubes (Basis Price), lb.	0 1 0½
,, Condenser, lb.	0 1 2½
Lead, English	22 15 0
,, Foreign	21 15 0
Spelter	26 17 6
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

Tungsten Metal Powder	1/10 per lb.	
Ferro Tungsten	1/5 per lb.	
	Per Ton.	Per Unit.
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£21 10 0	7/6
,, ,, 6 p.c. to 8 p.c.	£20 10 0	7/-
,, ,, 8 p.c. to 10 p.c.	£20 0 0	6/-
,, ,, Specially refined		
,, ,, Max. 2 p.c. carbon	£33 0 0	12/-
,, ,, ,, 1 p.c. carbon	£37 0 0	15/-
,, ,, ,, 0·70 p.c. carbon	£42 0 0	17/-
,, ,, ,, carbon free	1/- per lb.	
Metallic Chromium	2/7 per lb.	
Ferro Manganese (per ton)	£13 15 0 for home	
	£13 10 0 for export	
,, Silicon, 45 p.c. to 50 p.c.	£12 0 0 scale 5/- per unit	
,, ,, 75 p.c.	£19 0 0 scale 6/- per unit	
,, Vanadium	14/- per lb.	
,, Molybdenum	4/3 per lb.	
,, Titanium (carbon free)	1/2 per lb.	
Nickel (per ton)	£170 to £175	
Ferro-Cobalt	9/- per lb.	

FUELS.

SCOTLAND.

(Prices not stable.)

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	14/-
,, ,, Ell	16/-
,, ,, Splint	16/3 to 17/-
,, ,, Trebles	14/9 to 15/6
,, ,, Doubles	13/9 to 14/-
,, ,, Singles	13/-
AYRSHIRE—	
(f.o.b. Ports)—Steam	13/6
,, ,, Jewel	16/6
,, ,, Trebles	16/-
FIFESHIRE—	
f.o.b. Methil or Burntisland—Steam	12/9 to 13/6
Screened Navigation	18/-
Trebles	15/6 to 16/6
Doubles	13/3 to 13/9
Singles	12/9
LOTHIANS—	
(f.o.b. Leith)—Best Steam	13/6
Secondary Steam	13/-
Trebles	15/6
Doubles	13/6 to 13/9
Singles	12/9

ENGLAND.

(8) N.W. COAST—	
Steams	23/-
Household	38/6 to 51/-
Coke	22/-
NORTHUMBERLAND—	
Best Steams	14/3
Second Steams	13/- to 13/6
Steam Smalls	9/-
Unscreened	11/9 to 13/-
Household	21/- to 37/-
DURHAM—	
Best Gas	14/9
Second	13/3 to 13/6
Household	21/- to 37/-
Foundry Coke	18/6 to 19/6
SHEFFIELD—	Inland.
Best Hand-picked Branch	26/- to 27/6 —
Derbyshire Best Bright House	23/- to 24/6 —
Best House Coal	20/6 to 21/6 —
Screened House Coal	17/- to 18/- —
,, ,, Nuts	16/- to 18/- —
Yorkshire Hards	14/6 to 16/- —
Derbyshire Hards	14/6 to 16/- —
Rough Slacks	8/6 to 9/6 —
Nutty Slacks	4/6 to 6/- —
Smalls	3/6 to 4/- —
Blast-furnace Coke (Inland)	14/6 at ovens —
Furnace and Foundry Coke (Export), f.o.b.	19/- to 19

CARDIFF— (9) SOUTH WALES.

Steam Coals:	
Best Smokeless Large	19/3 to 19/6
Second Smokeless Large	18/- to 19/3
Best Dry Large	18/6 to 19/-
Ordinary Dry Large	17/6 to 18/-
Best Black Vein Large	17/9 to 18/-
Western Valley Large	17/3 to 17/6
Best Eastern Valley Large	17/- to 17/3
Ordinary Eastern Valley Large	16/6 to 16/9
Best Steam Smalls	12/6 to 13/-
Ordinary Smalls	10/6 to 12/-
Washed Nuts	18/- to 24/-
No. 3 Rhondda Large	19/6 to 20/-
,, ,, Smalls	14/- to 14/6
No. 2 ,, Large	16/- to 16/6
,, ,, Through	14/6 to 15/6
,, ,, Smalls	11/- to 12/-
Foundry Coke (export)	27/- to 37/-
Furnace Coke (export)	19/- to 21/-
Patent Fuel	20/- to 21/6
Pitwood (ex ship)	27/6 to 27/9
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	34/- to 35/6
Seconds	24/6 to 28/6
Red Vein	22/- to 27/-
Machine-made Cobbles	40/- to 43/6
Nuts	36/- to 43/6
Beans	23/6 to 25/-
Peas	16/6 to 17/6
Breaker Duff	8/- to 9/6
Rubbly Culm	9/3 to 9/6
Steam Coals:	
Large	17/6 to 18/6
Seconds	16/- to 17/-
Smalls	10/- to 12/6
Cargo Through	15/- to 16/-

(1) Delivered. (2) Net Makers' Works. (3) f.o.t. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (a) Delivered Glasgow. (b) Delivered Sheffield.

(c) Delivered Birmingham. (d) Rebate 12/6 joists and 10/- all other materials if home consumers confine purchases solely to British products.

French Engineering Notes.

(From our own Correspondent in Paris.)

Industrial Activity.

THE year closes with a readjustment in the situation generally, which may exercise an adverse influence in some directions, but is certainly proving beneficial in others, notably in a steady and growing improvement in the manufacturing trades following upon an increased activity in public and private enterprise at home. Around Paris there is so much business offered that it is not always possible to get it executed, and manufacturers are experiencing great difficulty in obtaining a sufficient supply of skilled labour. In other districts the situation appears to be nearly as good. One cause of this is the encouragement offered by the financial stability to private enterprise to carry out constructive work of all kinds, which has remained in abeyance for some years past, and another is the considerable number of public works being put into execution, partly with the aid of German reparations. At the National Congress of Public Works held recently in Paris, no fewer than twenty-five schemes of national importance were considered. They included, particularly, port extensions, inland waterways, transport generally, colonial railways, electrification, the Trans-Saharan railway, the carrying out of which must provide employment for many years to come. The country has entered upon a period of great engineering development, which depends largely upon the assistance to be rendered by Germany, and, so long as that is forthcoming in the form of reparations, there will be a continuance of activity in all branches of the engineering trades. On the other hand, the outlook is far less satisfactory as regards the export trade, which has been steadily declining all through the year, so that the adverse "balance of trade" has become a serious matter. Especially is this the case with the exports of manufactured goods. There is, indeed, a feeling of uneasiness over the future, which is due to the rising indices of living costs and the agitation that is growing for higher wages. Production costs are advancing, and it is feared that if they should continue to do so, foreign competition is likely to become a disturbing factor. For that reason consumers are ever on the alert to combat any tendency towards a rise in raw material prices, particularly of coal and iron and steel, and so far they have succeeded. Contrary to what had been expected, steel prices have become somewhat weaker. It is uncertain whether this will continue, for the French mill and forge owners are looking forward to an increasing home demand, and as steel producers have exceeded their quota they unsuccessfully endeavoured, at the meeting of the Steel Union in Paris last week, to get a larger production allotted to them, and it was decided to make no change in the production during the next three months.

Railway Electrification.

The Midi Railway Company has presented to the Minister of Public Works a project for the electrification of the section of railway between Béziers and Neussargues. This line has a length of 170 miles, and has to deal with a heavy traffic through difficult country, with many long gradients. The electrification will permit of an acceleration of the service with heavier trains. The energy will be supplied by the hydro-electric power stations in the Pyrenees and the Massif Central, which will be connected up by a high tension main from Toulouse to Millau. When it is completed the whole of the Midi system, having a length of 685 miles, will be electrified. Prominence is given to the fact that the Midi Railway Company is no longer a customer for British coal, considerable quantities of which it took before the electrification scheme was started upon.

Nautical Exhibition.

The annual Nautical Exhibition held in the Grand Palais, Paris, is organised more particularly with a view of creating a popular interest in maritime and naval matters, and the participation of the Department de la Marine is rendered spectacular by an exact reproduction of a torpedo boat. On the whole, it cannot be said that the Exhibition was quite so successful as on previous occasions. There were numerous exhibits, but the absence of most of the big shipping companies deprived the show of much of its former interest. An outstanding feature was the prominence given to Diesel and other types of oil engines of foreign construction. They were shown particularly by German firms, which seem to be getting a hold on this market at a time when the French are still behindhand in the construction and use of Diesel marine engines. In the smaller types, Peugeot and the Société Lilleise are manufacturing the Junkers engine with opposed pistons. Except for these latter there was little amongst the French exhibits in the way of heavy oil marine engines, apart from paraffin engines, and the high-powered petrol engines were less prominent than formerly. The Lorraine Company alone showed high-powered petrol engines, the biggest being one of six cylinders of 500 horsepower. The Americans exhibited a few powerful heavy oil engines, and, more particularly, detachable petrol motor and propeller equipments for small boats, the number of these, of different types, being quite large. There is obviously a good opening in this country for heavy oil marine engines, particularly for the fishing fleet, which is undergoing a complete transformation with the equipment of motors.

Air Ports.

Following upon the creation of the Air Ministry active preparations are being made for the carrying out of a programme which aims first at the laying out of "air ports" and the installation of lighthouses along the main routes, particularly between London and Marseilles, whereby it will be possible to run the air services at night. At Lyons, Marseilles and Bordeaux preparations are already being made for the laying out of "air ports," and during the past week official visits were made to Ronchin, near Lille, where the Chambers of Commerce of Lille, Tourcoing and Roubaix have decided to lay out a vast aerodrome.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

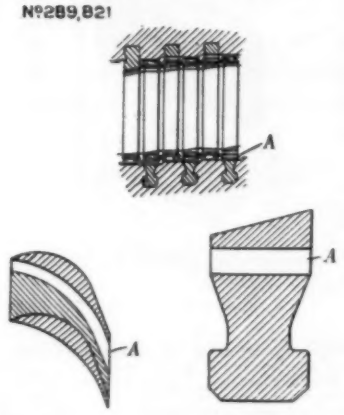
Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

TURBINE MACHINERY.

289,821. May 2nd, 1928.—STEAM TURBINE BLADING, The International General Electric Company, Inc., 120, Broadway, New York, U.S.A.

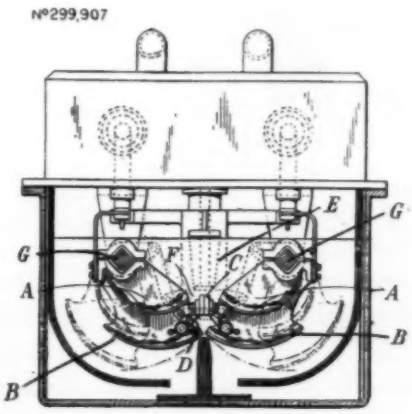
The inventors argue that the steam which leaks past the ends of the blading causes eddies in the main flow of steam through the blading and consequently impairs the efficiency of the turbine. They consequently provide passages through the spacing pieces between the blades, to lead away the leakage steam and prevent it mingling with the main body of steam. These passages are marked A in the drawings. In the case of the spacers for the moving blades the passages are curved, so that the leakage steam may do useful work.—*November 15th*, 1928.



SWITCHGEAR.

299,907. August 4th, 1927.—ELECTRIC OIL BREAK SWITCHES, A. Reyrolle and Co., Ltd., of Hebburn-on-Tyne, Durham; William Anderson, of 10, Park-road, Hebburn-on-Tyne, and Norman Cooke, of 67, Otto-terrace, Sunderland.

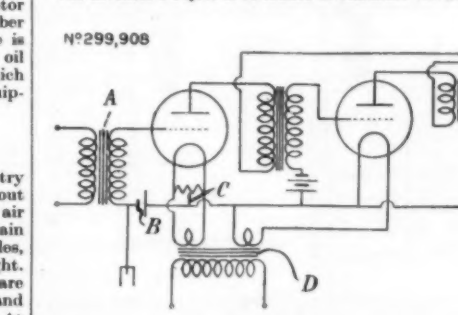
The contact-carrying arms A of the oil switch described in this specification are so constructed that, when they move to separate the contacts, the motion tends to force the oil against the moving arc and break it. The arms have curved concave vanes or blades B. The contacts C are mounted on pivoted arms, provided with springs. In the particular construction illustrated the contacts D are only arcing contacts and the main contacts are in another part of the tank. The fixed main contacts are indicated at E and the movable contacts at F. When the shafts G are rocked the arc formed between the contacts C is drawn outwards and moved downwards, and the curved vanes B B force the oil upwards on each side of the arc splitter, and the arc is very quickly broken.—*November 5th*, 1928.



TELEGRAPHS AND TELEPHONES.

299,908. August 4th, 1927.—THERMIONIC VALVE CIRCUITS, De Witt Clinton Tanner, of 195, Broadway, New York.

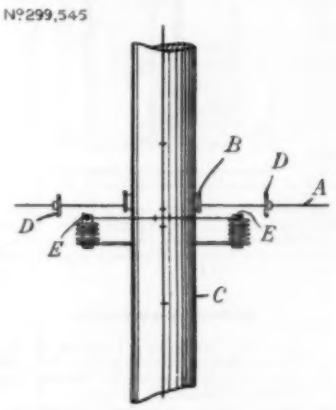
The inventor's object is to reduce or eliminate the hum produced by feeding the filaments of thermionic valves with alternating current. The secondary winding of the input transformer A is connected at one end to the grid of the first valve, the other end being connected to earth and through a grid bias battery B to the adjustable contact C of a potentiometer shunted across the filament of the valve. The transformer D which supplies the alternating current to the filaments has two secondaries, one for each filament. By adjusting the contact C, the hum oscillations which are produced in the grid circuit of the second valve by the alternating current in its filament may be neutralised by oscillations produced in the first valve. If there is insufficient adjustment to permit of a satisfactory balance being obtained, a resistance may be connected in series between one end of the potentiometer and the filament leg, extra turns being provided upon the corresponding secondary winding of the supply transformer D, so that the correct difference of potential across the filament may be maintained. The circuit connections that have not been referred to are self-explanatory.—*November 5th*, 1928.



TRANSMISSION OF POWER.

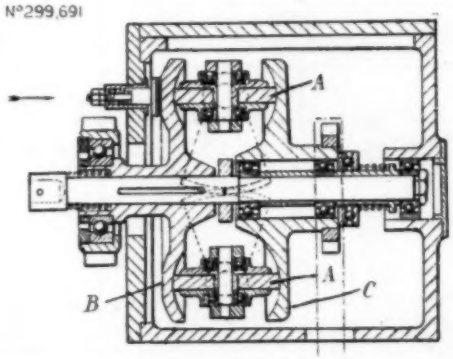
299,545. August 10th, 1927.—ELECTRICAL TRANSMISSION LINES, John Collier, of 63, Bridge-street, Manchester.

The line conductor A passes through sleeve insulators B in the pole C and to the conductor small metal contact pieces D are attached. In the event of the conductor A breaking or sagging excessively at some intermediate point, the wire is drawn through the insulator and one or more of the contact pieces D are drawn up against the terminal blocks E, which are connected to the neutral wire or earth direct. The line is therefore short-circuited and made "dead."—*November 1st*, 1928.



299,691. January 2nd, 1928.—CHANGE-SPEED GEARING, E. Christiansen and C. O. Ericsson, 100, Moor-street, Birmingham.

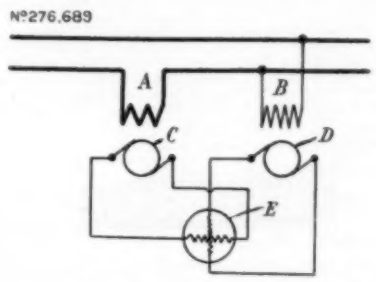
This change-speed gear is of the friction type, and with it variations of speed are obtained by varying the angle of the discs A A between the driving and driven members B and C. The cages carrying the friction discs are interconnected, so that they move in unison.—*November 1st*, 1928.



MEASURING AND TESTING INSTRUMENTS.

276,689. August 26th, 1927.—AN IMPROVED SYSTEM FOR MAKING ELECTRICAL MEASUREMENTS IN DIRECT-CURRENT CIRCUITS, Istrumenti di Misura C.G.S., Società Anonima, of Via Montenapoleone 39, Milan, Italy.

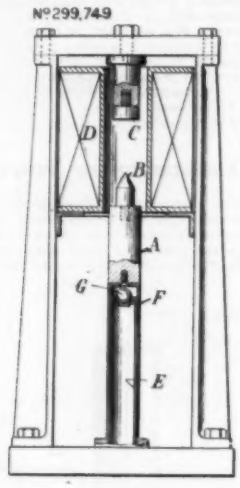
Owing to the fact that transformers cannot be employed, and owing to insulation difficulties, the measurement of current on high-pressure direct-current circuits is not easy. According to this invention, the difficulties are overcome by the use of two field windings, a series winding A and a shunt winding B, and two armatures C and D, which are connected in series and to a wattmeter E with fixed and movable coils. The armatures are revolved at constant speed.—*November 8th*, 1928.



299,749. July 30th, 1927.—APPARATUS FOR MEASURING ELECTRIC CURRENTS, A. Reyrolle and Co., Ltd., of Hebburn-on-Tyne, and Henry William Clothier, of "The Green," Wallsend-on-Tyne.

The apparatus described in this specification is for measuring heavy currents of short duration, such as those produced by short circuits. A plunger A is provided with a hardened steel point B. The normal current passing through the coil D is

insufficient to lift the plunger, but an abnormal current causes the plunger to rise and the point B makes an indentation in the lead button C, and the depth of this indentation is a measure of the current. Oscillation of the plunger is prevented by partially closing in the top of the fixed guide tube E, so that it forms a

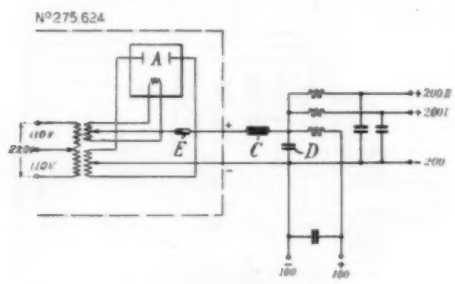


seating F for a ball G. This ball acts as a valve and allows the free upward movement of the plunger under the influence of the coil, but exercises a certain amount of retarding influence on its return movement, thus producing a cushioning or dashpot effect.—*October 30th*, 1928.

MISCELLANEOUS.

275,624. August 3rd, 1927.—THE FEEDING OF THERMIONIC VALVES FROM A SOURCE OF CURRENT CONTAINING DISTURBING COMPONENTS, Siemens and Halske Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

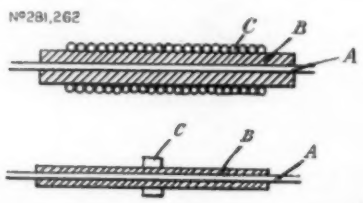
If the plate current for thermionic valves is taken from a direct-current circuit or, after rectification, from an alternating-current circuit, disturbing noises are liable to become perceptible. They are caused by alternating-current components superimposed on the plate current. The action of these disturbing currents becomes so strong with a large number of valves that hitherto it has been considered that the only means for their elimination is the use of several large and therefore uneconomical choking coils and shunt capacities. According to the invention, this defect is eliminated by the fact that to each valve or group of valves a separate filter circuit, dimensioned according to the current strength and filter effect required, is added. The current



at 220 volts is rectified in the usual way by means of a rectifier A, with a transformer. In the outgoing wires a choking coil C, a bridging condenser D of approximately 8 MF, and a fuse E are provided. From there several resistance circuits of different dimensions are branched off—a circuit with a filter chain consisting of a resistance of 60,000 ohms, and a capacity of approximately 2 MF leads to the valve which is the most sensitive, but which has the smallest current consumption—the audion valve—the valve being connected to the + and − 100-volt terminals. A second group of valves less sensitive, but requiring larger currents, is connected to the terminals + 200[I] and − 200. This branch comprises a filter circuit with a resistance of 25,000 ohms, and a capacity of 2 MF. The last, the least sensitive valve group, requiring, however, the greatest current value, is connected to the terminals + 200[II] and − 200, the current of which flows over a filter circuit with a resistance of 300 ohms and a capacity of 4 MF.—*November 5th*, 1928.

281,262. November 10th, 1927.—ELECTRON EMITTING CATHODES, La Radiotechnique, of 12, Rue La Boetie, Paris.

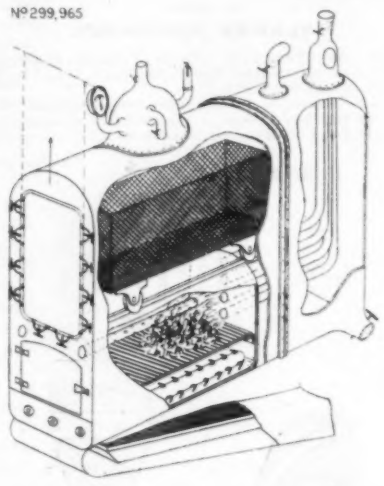
The advantages of this invention lie in the ease with which the process of manufacture of electron-emitting cathodes can be carried out, and the thinness of refractory insulating enamel on the core which can be obtained. A refractory metal wire, say, tungsten, for example, preferably of fairly large diameter, is heated to a temperature of about 3200 deg. in a bed of powdered magnesia. Under these conditions the wire is coated with a layer of refractory and insulating enamel. Upon the coating a thoriated tungsten filament is afterwards wound,



and may be left free at one end, in which case the cathode connection is ensured by passing through the shell of the vacuum tube or valve a special conductor, or by connecting the other end to one of the conductors supplying current to the coated wire, which avoids any special projection of the cathode. According to the upper drawing, a core composed of a metal wire A is covered in the manner described with a refractory and insulating coating B upon which there is wound spirally a metal wire C, having strong electron-emitting properties at a relatively low temperature. According to the lower drawing, the electron-emitting material C is concentrated in the form of a ring in the central part of the coated core. The cathode, according to the invention, may be applied to any kind of tubes or valves having several electrodes, the manufacture of which will be conducted according to any known methods.—*November 8th*, 1928.

299,965. September 24th, 1927.—THE MANUFACTURE OF PAPER, G. A. Mourlaque, 6, Cité Bergère, Paris, France.

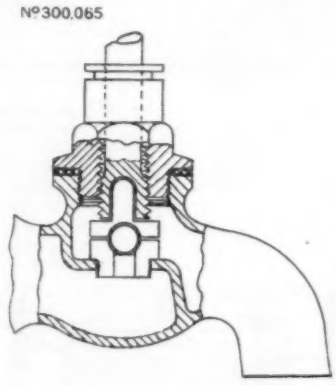
The inventor proposes to produce paper pulp by treating vegetable matter first with ozone and then with a solution of potash and lime. The material is held in the basket shown in the upper part of the boiler. It is first subjected to ozone at a pressure of from 3 to 4 atmospheres for a period of about two hours. The boiler is then filled with solution and a fire lighted beneath



the boiler and pressure raised and maintained so long as may be necessary. The lixivium is drawn off and any waste vegetable material it may contain is injected into the fire-box with the object of recovering its potash in the cinders. The same fire is also used for calcining the necessary lime. After washing, it is claimed, the pulp is suitable for making wrapping paper.—*November 8th*, 1928.

300,065. March 8th, 1928.—VALVES AND COCKS, A. Eastwood, sen., and A. Eastwood, jun., 15, Newburn-road, Tinsley, Sheffield.

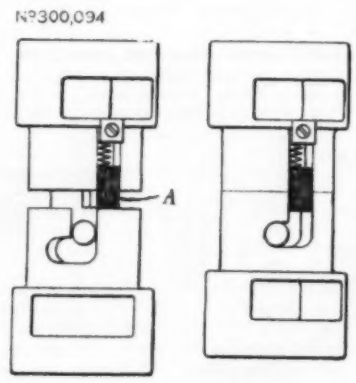
It seems unnecessary to go beyond the following extract from this specification:—"In taps, cocks, and the like devices the provision and use of detachable valve, valve seat and valve closing members, all made of stainless steel, and characterised in that a spherical valve or closure member is operated under



the pressure of a closing member having a fitting cavity which is in part spherical, and a perforated valve seat member with a seating cavity in the form of a portion of a sphere; the centres of the spherical portions of both the valve seat and the closing member being—in the 'closed' position—coincident or nearly so with the centre of the spherical closure member, and opposing parts of the closing member and the valve seat member then approaching contact in a plane."—*November 8th*, 1928.

300,094. May 8th, 1928.—CONNECTING DEVICES FOR PARACHUTES, A. C. Rowden, 432A, Edgware-road, London, W. 2.

This connector is put forward primarily for parachute purposes, but might be used for a variety of other services. It is of the bayonet socket type and is noteworthy on account of the safety bolt A, which springs into the bayonet slot when the two



parts are engaged and prevents mutual rotation, so that the two parts cannot be accidentally disengaged. When it is desired to separate the two parts of the connector the bolt is pulled back with the assistance of its roughened outer surface. The illustrations show the connector about to be engaged and fully locked.—*November 8th*, 1928.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. Informal meeting. "Oils for Cutting and Quenching Purposes," by Mr. C. H. Hudson. 7.30 p.m.

FRIDAY, JANUARY 11TH, 1929.

MANCHESTER ASSOCIATION OF ENGINEERS.—Midland Hotel, Manchester. Annual Dinner. 6.45 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

FREDK. J. GORDON AND CO., Ltd., of 92, Charlotte-street, London, W. 1, ask us to announce that they have been appointed sole agents for the British Isles for the B. C. Ames Company, of Waltham, Mass.

ERITH'S ENGINEERING COMPANY, Ltd., of 83, Kingsway, W.C. 2, ask us to announce that, following on the death of the late Mr. W. J. H. Diplock, two new directors have now been appointed, viz., Mr. Roger Stewart Erith and Mr. Herbert Kidson, F.C.A.

THE ENGINEERING AND COMMERCIAL COPYING COMPANY asks us to announce that it has made its business into a limited liability company, the title and address of which will be the Engineering and Commercial Copying Company, Ltd., 137, Victoria-street, S.W. 1.

JOHNSON AND PHILLIPS, Ltd., of Charlton, S.E. 7, ask us to announce that, owing to the necessity for increased office and storage accommodation, their London office has been moved from 12, Union-court, E.C. 2, to Columbia House, Aldwych, W.C. 2. Telephone numbers, Holborn 8326, 8327 and 8328.

THE UNDERFEED STOKER COMPANY, Ltd., of Africa House, Kingsway, London, W.C. 2, asks us to announce that it has entered into arrangements with the Combustion Engineering Corporation, of New York, and the Société Anonyme des Foyers Automatiques, of France, whereby the latter are licensed to sell throughout their respective territories the new "L" type travelling grate stoker, designed and patented by the Underfeed Stoker Company.

THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., and the Metropolitan-Vickers Electrical Export Company, Ltd., ask us to announce that on December 28th they will be moving from 4, Central-buildings, Westminster, to Bush House, Aldwych, W.C. 2. The Home Sales Department of the Metropolitan-Vickers Electrical Company, at present in Metrovick House, Charing Cross-road, will move into Bush House on January 7th, but Metrovick House will remain the headquarters of Metrovick Supplies, Ltd. The new telephone number at Bush House will be City 1230 (ten lines), and the telegraphic address "Multophase, Estrand, London."

CALENDARS, DIARIES, &c., FOR 1929.

BRITISH INSULATED AND HELSBY CABLES, Ltd., Prescot, Lancs.—Refill cards for desk calendar.

CROFTS (ENGINEERS), Ltd., Bradford.—Wall calendar with monthly tear-off sheets.

D.P. BATTERY COMPANY, Ltd., Bakewell, Derbyshire.—Wall calendar with monthly tear-off slips.

DRAUGHTSMAN, THE, 96, St. George's-square, London, S.W. 1.—Copy of the Association of Engineering and Shipbuilding Draughtsmen Diary.

WM. JESSOP AND SONS, Ltd., Brightside Works, Sheffield.—Wall calendar with daily tear-off slips.

JOHN ROGERSON AND CO., Ltd., Wolsingham, S.O., Co. Durham.—Wall calendar with monthly tear-off sheets.

SHAW AND BLAKE, Ltd., 8, Bell Yard, Temple Bar, London W.C. 2.—Wall calendar with monthly tear-off sheets.

WAILES DOVE BITUMASTIC, Ltd., 5, St. Nicholas-buildings, Newcastle-on-Tyne.—Copy of the Bitumastic pocket diary and note book.

CROSSLEY BROS, Ltd., Openshaw, Manchester.—Wall calendar with monthly tear-off sheets.

HULSE AND CO., Ltd., Ordsal Works, Manchester.—Wall calendar with monthly tear-off sheets.

STAVELEY COAL AND IRON COMPANY, Ltd., near Chesterfield.—Pocket diary.

METCHIM AND SON, 8, Princes-street, Westminster, S.W. 1.—Copy "Surveyors' Tables and Diary."

THOS. ROBINSON AND SON, Ltd., Rochdale.—Wall calendar with monthly tear-off sheets.

THE JUNIOR INSTITUTION OF ENGINEERS.—At the weekly meeting, held on Friday, December 14th, Mr. E. J. H. South, member, read a paper describing the advantages to be gained by washing out the boilers of locomotives with hot water instead of the much more general method by means of cold water, adopted in England. He stated that locomotive boilers were peculiarly susceptible to become furred and encrusted owing, firstly, to the rapid evaporation, and, secondly, to the use of water obtained from different sources in various parts of the country, and although plants for softening and treating water were installed at a great many of the large stations and locomotive sheds up and down the country, there were hundreds of branch and local lines which had no such installation. The advantages of using hot water were threefold. First, it did not impose that strain on the structure of the boiler which, it was contended, resulted if cold water was introduced to a boiler not sufficiently cooled after its contents had been blown off; secondly, it enabled a saving of several hours in the time taken to blow out, wash, refill and generate steam, and thus enabled a smaller number of engines to do a given amount of work; and thirdly, by modern systems the hot water remaining in a locomotive boiler sent to the sheds for washing down was not blown to waste, but used to heat the water used in refilling the boiler after washing.